DEVELOPMENT, GROWTH, AND STATE OF THE ATOMIC ENERGY INDUSTRY

HEARINGS

BEFORE THE

JOINT COMMITTEE ON ATOMIC ENERGY CONGRESS OF THE UNITED STATES

EIGHTY-SIXTH CONGRESS

SECOND SESSION

ON

DEVELOPMENT, GROWTH, AND STATE OF THE ATOMIC ENERGY INDUSTRY

1960

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DEVELOPMENT, GROWTH, AND STATE OF THE ATOMIC ENERGY INDUSTRY

TUESDAY, FEBRUARY 16, 1960

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
Washington, D.C.

The committee met, pursuant to notice, at 2 p.m., in room P–63, the Capitol, Senator Clinton P. Anderson (chairman of the Joint Committee) presiding.

Present: Senators Anderson, Hickenlooper, and Aiken; Representatives Price, Aspinall, Van Zandt, Hosmer, and Westland.

Also present: James T. Ramey, executive director; John T. Conway, assistant director, David R. Toll, staff counsel, and George F. Murphy, Jr., professional staff member.

Chairman ANDERSON. The committee will be in order.

Today we begin our public hearings on the development, growth, and state of the atomic energy industry, as required by section 202 of the Atomic Energy Act of 1954.[1] The Atomic Energy Commission will lead off the testimony today, and we expect they will finish their testimony tomorrow afternoon. Approximately 27 representatives of industry and other interested groups and individuals will testify on Thursday afternoon and Friday morning, and on a half-day basis for probably the next week. The AEC and industry witnesses were invited to discuss the following subjects:

1. The AEC's 10-year civilian power program.
2. Military reactor programs, including the Army reactor program as it affects industry and the Navy reactor program as it affects industry.
3. Maritime reactor program.
4. AEC contract policies and how they affect industry.
5. Industrial development and uses of radioisotopes.

The main focus of the hearing will be on AEC's 10-year civilian atomic power program, but I am hopeful we will also have time to discuss industry aspects of our naval reactor program and our military package power projects as well as the industry aspects of the radioisotope program. Some discussion of the regulatory program will also be helpful.

This will be your second year with us at these hearings, Mr. McCone. Last year you will recall there were a few misunderstandings on both sides in relation to your presentation. I am glad to say that our subsequent hearings and activities developed the most cordial relationship between the Commission and the committee and its staff.

[1] Announced in Joint Committee Press Release No. 253, dated Jan. 22, 1960. Atomic Energy Commission notified by letter dated Jan. 6, 1960.

In saying this, I must recognize we have had some disagreements on the proposed atomic power projects initiated by the Joint Committee or on which the Joint Committee was interested such as the Oak Ridge gas-cooled experimental prototype, the Puerto Rico superheat reactor, the boiling water project in the second round, and the organic project in the third-round power demonstration program.

I am glad to say that the Commission after some consideration has proceeded with the projects as contemplated by the Joint Committee on Atomic Energy. I might add that this has been a matter of extreme pleasure to me and I know to other members of the committee to have this very fine cooperation from the Commission.

The Commission's presentation of the 10-year atomic power program marks a milestone in the Commission's program planning. The need for such longer term planning was set forth in July 1957 in the Joint Committee report on the AEC authorization bill for fiscal year 1958. In the fall of 1957 Mr. Carl Durham, our chairman, proposed that the AEC and the Joint Committee informally develop a mutually agreed on 5- to 10-year program. Although since July 1958 the Commission has preferred to follow the traditional methods of presenting its proposals to the Joint Committee, progress has been made in developing mutually agreed upon objectives and methods, and some consultation has been made. In reviewing the AEC 10-year program and the discussions which follow, I hope that the following questions will be considered at appropriate times:

One, I note a big gap in prototype construction with no starts from now until fiscal 1962. What is going to happen to our atomic equipment industry during this 2½-year period?

Two, what effect will the failure of the Euratom program have upon the domestic atomic equipment industry? Should consideration be given to allotting to our domestic program some of the funds which would have gone into the international program?

Three, I note at the end of your statement a brief paragraph on the cost of the program. We requested a more detailed explanation of the cost. In the past the provisions of the cost projections have been extremely difficult to work out.

Four, what measures do you recommend to expedite our schedule on atomic power projects? You publicly called attention to this problem and contrasted our method with the Russians. I might point out that we have been provided with a great deal of information and data in the form of various reports along with the AEC statement which Mr. McCone will give. Thus we have the AEC annual report which is on the state of the atomic energy industry. We have a special report on radioisotopes. We have our annual statement updating AEC cost estimates on the civilian atomic power program, and we requested certain additional cost information as mentioned above. Undoubtedly other documents have been or will be received during these hearings.

(A letter from James T. Ramey, executive director, Joint Committee on Atomic Energy, to Gen. A. R. Luedecke, General Manager, AEC, dated February 26, 1960, regarding the above questions, as well as other questions that arose during the hearings, and the Commission's response, in the form of a letter to Senator Anderson,

Chairman, Joint Committee on Atomic Energy, from Acting Chairman John F. Floberg, AEC, dated March 7, 1960, will be found on pp. 148–149.)

Chairman ANDERSON. Accordingly, it may be that the Joint Committee will not be in a position to consider adequately all the material presented and may wish to go a bit further near the conclusion of these 202 hearings or in connection with the authorization hearings.

I am very happy to have you with us today, Mr. McCone, and to welcome you and your associates on the AEC, and the AEC staff members.

May I end up by saying that, Mr. McCone, it has been a very pleasant year as far as I am concerned. I think it has been a profitable year, since you have been with us last, and I look to your testimony with a great deal of satisfaction and comfort. We are happy to have you here.

STATEMENT OF JOHN A. McCONE, CHAIRMAN, ACCOMPANIED BY COMMISSIONER JOHN S. GRAHAM, COMMISSIONER JOHN F. FLOBERG, DR. JOHN H. WILLIAMS, COMMISSIONER, DR. FRANK K. PITTMAN, DIRECTOR, DIVISION OF REACTOR DEVELOPMENT, AND GENERAL MANAGER A. R. LUEDECKE AND OTHER STAFF MEMBERS, ATOMIC ENERGY COMMISSION [1]

Mr. McCONE. Thank you very much, Mr. Chairman. I would like to express myself and also the feeling which I am sure is that of Commissioner Floberg and Commission Graham and Dr. Williams, that we are most gratified for the cordial and considerate manner we have been treated by you personally and by your committee, and for the cooperation extended by the staff, who have worked diligently and cooperatively with us. I am very happy to hear your remark and realize that our feeling is reciprocated by the feeling which you expressed.

We have submitted a prepared statement which I will read.

Chairman ANDERSON. May I say to you, Mr. Chairman, that we appreciated very much, since this is a relatively long statement, the fact that we had it many days in advance, instead of the 24 hours in advance that the Reorganization Act might have required. We had it a long time in advance, have had a chance to go over it, and the staff appreciated that fact very much. Every member of the committee has had it for 2 or 3 days.

Mr. McCONE. I have a few opening remarks which have not been distributed because the time did not permit it to be mimeographed. With your permission I would like to read it, and then I will tell you when I start with the statement, a copy of which has been submitted to you.

Chairman ANDERSON. You go right ahead.

Mr. McCONE. In presenting the Atomic Energy Commission's testimony for this year's 202 hearing, we would like with your permission to discuss, first, the nuclear power program, particularly the conclusions we have drawn from the 10-year study we have recently completed. I will present this portion of the Commission's testimony.

[1] The full statement of the Atomic Energy Commission appears, starting on p. 122.

Mr. McCone. This will be followed by testimony on the international program, industrial activities, and isotope development to be presented by Commissioner Floberg. Mr. Graham will present our views on regulatory matters, contract policy, patents, and fuel supply. The oral testimony of Commissioners Floberg and Graham will discuss programs on which you, Senator Anderson, requested comment in your letter of January 6.

As written testimony, we would like to present for reference the Commission's Annual Report to Congress for 1959. This is the report which you referred to. This report describes the progress of the industry during the year 1959, related Commission's programs, and other major activities in which members of the committee have expressed a special interest. The annual report incorporates a special report on management of radioactive wastes and a summary of what we know and are seeking to learn about fallout from weapons tests.

We have also submitted for reference a special report called "Radioisotopes in Science and Industry (January 1960)." Testimony covered by the other Commissioners and myself represents the major segments of our presentation.

I would like to preface our remarks by informing the committee that the views expressed by me and by my fellow Commissioners represent the unanimous views of the Commission. In discussing the power program, I will outline our conclusions concerning the experimental, prototype, and large-scale reactors which we believe should be built to advance this technology.

I wish to emphasize two things at the outset. First, plants which we envisage as essentially building blocks in the program are not by any means all of the plants which will be built in the United States during the next 10 years. It is our opinion that as each successive step in our program shows possibilities of lower cost plants and cheaper power, publicly and privately owned utilities will themselves build plants with or without Government aid in order to meet their ever-growing demand for electric power. Many of these plants will be built for the sole purpose of meeting power demands and will not be developmental units as such. However, it may be in the interest of the objectives of the Commission to support these undertakings through research and development assistance and fuel waiver where conditions warrant such participation.

My conclusion as to this possibility is prompted by the dramatic developments in diminishing capital costs and lowering power costs of two of the most advanced reactor concepts, the pressurized and the boiling water designs. You are familiar with the fact that the GE Co. has offered a 300-megawatt electrical boiling water plant to the utility industry at a capital cost of about $200 per kilowatt, and a guaranteed fuel life which has the effect of assuring satisfactory resulting power costs. The Westinghouse Co. has offered a pressurized water plant on about the same basis.

These plants, I might say, are offered on a fixed-price basis, and this is a very satisfactory arrangement from the standpoint of the utilities. These figures are significantly lower than the cost of the several plants now under construction or nearing completion which are based on the technology of 1955 to 1957. Moreover, these estimates are substantially lower than the figures developed through studies

authorized by this committee 2 years ago, and presented to this committee by the Commission last spring. These proposals by the Westinghouse and General Electric companies have created a very great interest on the part of major utilities in California.

I can report to you, as I have previously, that active negotiations are underway for the construction of two plants totaling 600,000 to 650,000 kilowatts electrical, with engineering design and construction estimated to start in 1960. It is my hope and my belief that these negotiations will be consummated, and that these plants will come into being. Although some Government assistance might be needed for research and development, and possibly fuel charges, I am gratified to be able to inform you that the executives of the utility companies have reported to me that for the first time in the long and sometimes discouraging history of nuclear power development, they can consider the construction of these large plants on purely an economic basis in competition with conventional plants in areas of the United States where fuel is particularly expensive.

Secondly, I would like to emphasize that a 10-year look into the future of a new and rapidly developing technology such as nuclear power must be based on the best known technology and judgment of knowledgeable men concerning possible future developments. However, since this is a new and ever-changing science, the program must be kept flexible and adjusted from year to year to take full advantage of the evolving technology. The Commission must be alert to new developments and remain sufficiently flexible to take full advantage of them as they appear. This has been and will continue to be our policy.

Among other things, this policy will call for the construction of experimental plants and prototypes by the Commission itself, or under the conditions of second or third round for our power demonstration reactor program. With your permission, Mr. Chairman, I will now proceed with the prepared statement.

Chairman ANDERSON. Could we stop now for Senator Hickenlooper's question?

Senator HICKENLOOPER. I want to ask you a little bit more about these plants. Frankly, my question is motivated by some articles that have been appearing here in the last few weeks that the power program is a flop and failure, and that private enterprise is not interested in it, and that it just is not going any place.

You mentioned these two plants where proposals have been made which I understand will total somewhere between 600,000 and 650,000 kilowatts electrical. Are those to be built by private capital?

Mr. MCCONE. The negotiations, Senator, are between private power companies in California, and the Westinghouse and the General Electric Co. for two plants that will be built with private capital. There will be no Government money involved in the construction. It is not clear whether the power companies, if these negotiations are concluded—and they are just under negotiation—will request some assistance from the Commission in the way of research and development, or possibly the waiver of fuel charges for a period of 5 years. I do not know whether that request will be made. However, the encouraging point to me in the light of the statement that you made, or your reference to statements which have appeared concerning the fact that nuclear power is a flop—and I must say it is discouraging

at times—is the fact that here is an area in which the power interests have been seriously considering these two plants to meet their growing power demand, and not for the purposes of a developmental enterprise.

Senator HICKENLOOPER. That is one of the important parts of your statement that I was interested in, when you said that these proposals stem from basically economic considerations and not experimental considerations. In other words, that they apparently consider that these plants and the design and progress which has resulted thus far warrant them on an economic basis to go into the construction of these two plants; that is, it is worth while economically.

Mr. MCCONE. That is correct.

Senator HICKENLOOPER. I think this is especially important in view of the slowing down or possible abandonment—I don't know that it will be abandoned—of the Euratom program, and some of the other programs. Also, the slowing down of the atomic power development in Russia, which is more or less as freely predicted 3 or 4 years ago, and the other factors of fuel which affect the European programs.

Perhaps you touch on this later. I don't know. I am wondering whether or not you feel that this could be a step forward, in complete industrial private enterprise operations in this field of power production.

Mr. MCCONE. I think it is a step forward. I would point out that we are talking about plants in an area which is quite high-cost fuel area. Also, an area of large electrical consumption, and therefore large plants, can be appropriately used.

Senator HICKENLOOPER. And these plants would be used.

Mr. MCCONE. These plants would be used to meet the growing demand for power and on a competitive basis with conventional fuel in the area. There are other areas in the United States where this could happen today. There does not seem to be quite the initiative, or quite the need for a large plant. But we have hopes for further developments along this line.

Representative VAN ZANDT. Did you say, Mr. McCone, it would be $200 per kilowatt for construction?

Mr. MCCONE. Erected on a fixed-price basis; yes.

Chairman ANDERSON. May I interpose? As a matter of fact, Westinghouse—I don't know what the General Electric proposal is—has interviewed a number of utilities, said they have a 300,000-plus kilowatt installation that they will install for $68 million as a flat figure. I assume General Electric has a figure also somewhat in the neighborhood of $60 million for their 350,000-kilowatt plant. These are firm figures, are they not?

Mr. MCCONE. These are firm figures.

Representative VAN ZANDT. Could you translate it into mills per kilowatt hour?

Mr. MCCONE. That is difficult, Mr. Van Zandt, because that depends upon the factors of capital charges and load factor that the utility company itself uses as its standard. Some companies have longer periods of depreciation or amortization than others, and some estimate a higher load factor than others.

Representative VAN ZANDT. What is the average cost per kilowatt-hour for conventional power on the coast?

Mr. MCCONE. At a cost of 35 cents per million B.t.u. for fuel, and this is a reasonable current present-day cost on the west coast. The cost of power with estimated capital charges on a new efficient plant for 300 megawatts would be 7 mills.

Representative VAN ZANDT. Seven mills?

Mr. MCCONE. Yes.

Representative VAN ZANDT. You say these proposed plants will provide atomic power competitive with conventional fuel?

Mr. MCCONE. Over the life of the plant. Here comes in another factor of judgment where the power industry feels that conventional fuel is going to increase from year to year, because of inflationary pressures. But they look for the atomic fuel costs to come down because of the mass production of the fuel elements which, as you know, is a big increment of the cost.

Representative VAN ZANDT. Mr. McCone, have you identified these utility companies on the west coast who are going to negotiate for these plants?

Mr. MCCONE. Yes; I know the companies. I have talked to them. It has been reported here on the February 11 issue of the Nucleonic Magazine. It is Southern California Edison Co. and the Pacific Gas & Electric Co. I wish to emphasize to this committee that these negotiations have not been completed. We have not been told that they had signed contracts or have indeed made the selection as to the process. However, they are sufficiently serious so that they have had many conversations with me personally and with representatives of our staff.

(Correspondence from California Edison follows:)

SOUTHERN CALIFORNIA EDISON CO.,
Los Angeles, Calif., February 15, 1960.

Hon. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Washington, D.C.

DEAR SENATOR ANDERSON: There is enclosed for the information of the Commission an original signed duplicate of a letter dated and delivered this date to Hon. John A. McCone, Chairman of the Atomic Energy Commission, concerning the company's interest in a proposed 300,000-kilowatt atomic-fueled electric generating station.

Cordially yours,

HAROLD QUINTON.

SOUTHERN CALIFORNIA EDISON CO.,
Los Angeles, Calif., February 15, 1960.

Hon. JOHN A. MCCONE,
Chairman, Atomic Energy Commission,
Washington, D.C.

DEAR MR. MCCONE: You have heretofore been advised of the two proposals that have been made by manufacturers and constructors to the Southern California Edison Co. for the research, including extrapolation, design, engineering and construction of an atomic-fueled electric generating station of an approximate capacity of 300,000 kilowatts on this company's system. It is evident from these proposals that very substantial progress has been made in the economics of this new electrical art, and this letter will confirm the company's interest in the proposals.

They have been favorably viewed and considered since their initial receipt. Continuous evaluation studies of the proposals have been in progress, including a preliminary and informal discussion with members of the staff of the Com-

mission. As I am sure the Commission is aware, the construction of a plant of the size contemplated, whether atomic or conventional in type, must be expected to operate fairly promptly, after completion of construction, on baseload at full capacity. This is one of the several risks of an initial atomic plant of the untried dimensions involved. Our evaluations indicate several other areas of economic risk, and it will be the purpose of our continuing efforts to either eliminate or reduce these risks to a degree of reasonable prudence.

You have heretofore offered the assistance and counsel of your staff, and we should soon reach a point where further meetings with the staff would be helpful. Hopefully, we will be in a position to make a definitive decision, leading to an appropriate application to the Commission, within a period of not to exceed 6 months. However, we have not as yet determined that the proposed plants will be economically feasible on this company's system, and this letter should not be construed as a letter of intent to conclude any definitive arrangements at this time.

Very truly yours,

HAROLD QUINTON.

Representative VAN ZANDT. These two proposed plants would be in addition to the one that is already under construction; is that correct?

Mr. MCCONE. That is right.

Representative VAN ZANDT. Where is that?

Mr. MCCONE. That is at Humboldt Bay in northern California.

Representative VAN ZANDT. What is the name of the utility?

Mr. MCCONE. Pacific Gas & Electric Co.

Mr. WESTLAND. May I pursue this $200 per kilowatt a little further? Two hundred dollars does not sound like 7-mill power to me unless you are going to amortize the plant in 10 years. It is high by about five.

Mr. MCCONE. No; it is not. I think I can make a reference here, not referring to these projects, but I just happen to have an economic study on a project in another area of 330-megawatt plant at $236. The cost on a 28-year amortization, and this is not on private financing, but this is a publicly owned utility district financing, the capital costs will be about 2.5 mills, the fuel costs about 3.5 mills, and the operating cost about a half mill. So under that form of capital charges it would run about 6.5 mills.

Now, for a private utility they would have to have substantially heavier capital charges so the cost would be considerably higher.

Chairman ANDERSON. Weren't the figures somewhere just above 8 mills?

Mr. MCCONE. I would think that would be a good figure.

Chairman ANDERSON. Proceed, Mr. Chairman.

Mr. MCCONE. I will start with paragraph 2.

Senator HICKENLOOPER. May I ask just one more question, Mr. Chairman?

Another interesting point that you made, or that is being made in connection with the costs, is the anticipation that nuclear fuel may at least stay at approximately the same value or go down in cost in the future, whereas conventional fuels give every indication of going up in cost, which I think is an interesting observation so far as the economics of the plant over its plant life are concerned. This would enable them to level off the cost over a 20- or 25-year period, or whatever the period may be. I presume that would be an important part of the calculation of the cost, that is, the reliance upon nuclear fuels not going up in value particularly, but perhaps going down, and

conventional fuels giving every indication of increasing. That is an observation on my part.

Mr. McCone. Yes. The reasoning behind that is that the actual uranium, or the cost of the uranium, partially enriched as it is, represents a very small fraction of the total fuel charge. The balance is in the fabrication and in the estimated cost of reprocessing and in the burnup charges. As you know, to date there have been so few of these plants that the fabrication of the fuel elements has been a hand job, really. The anticipation is that when a sufficient number of plants come along, fuel elements will be fabricated by production methods, and the costs will come down materially. The reduction due to mass production would, in the opinion of industry and in our opinion, offset any rises due to inflationary pressures.

Senator Hickenlooper. Thank you.

Chairman Anderson. Proceed, Mr. Chairman.

Mr. McCone. In developing the program plans presented in the current report, primary attention has been given to the technological development required to achieve economically competitive nuclear power. Consequently, the development of prototypes for large central station powerplants figures prominently in the program.

This should not be construed as indicating a diminution of Commission interest in, or support of, a small power reactor program directed to achieving economically competitive nuclear power in plant size below 50 mwe.—electrical megawatts. A number of the reactors presently being built or planned will contribute to attaining this objective.

As more information becomes available and is evaluated concerning these and other reactors, including military programs, additional prototypes of small power reactors will be considered for construction.

Our current program follows the orderly three-phase sequence for the development of individual reactor concepts as described to this committee in our testimony last year. This sequence, in general, contemplates construction, first, of reactor experiments or experimental reactors, followed by prototypes and then by plants of commercial proportions.

It is the opinion of the Commission that the reactor experiments should be built and operated by the Commission. Prototypes should be built and operated by publicly or privately owned utilities independently or in cooperation with the Commission; alternatively, prototypes, in our opinion, could be built and operated by the Commission itself. The utility industry should assume the primary responsibility for large commercial-size nuclear power stations; however, the Commission will consider possible assistance on initial plants in various concepts useful for demonstration purposes.

We believe it important that the large plants and, as far as possible, the prototypes as well, be integrated into utility power grids in order to demonstrate load factors, dependability, and other operating characteristics which affect the economics of the plants.

Let me make clear that throughout I am dealing only with the plans of the Commission. We have not attempted to forecast what projects industry may wish to undertake independently. Based on

past experience, I am sure we can reasonably expect substantial participation in these plans.

I would like to add here that where throughout I mention industry, I am referring to both publicly and privately owned industry.

In the development, construction, and operation of prototype and full-size, power-producing reactors, the Commission will work cooperatively with reactor manufacturers and with publicly and privately owned utilities.

Any arrangements whereby the Commission provides significant financial support will include provisions to assure that an experimental testing program can be carried out with the reactor during its early operation. Testing programs will vary with each project. When power generation is involved, this fact will be taken into account when establishing the testing program.

We plan a continuing evaluation and reappraisal of our program. New ideas and new technologies, including those developed in other countries, will be reflected in this continuing evaluation.

Periodic program reviews will consider carefully the relative merits of various lines of development looking toward reduction or elimination of some efforts, and initiation of, or increases in others. Should information indicate that a concept is not useful in meeting our objectives, the concept would be dropped.

PROGRAM OBJECTIVES

In previous reports and testimony before the Joint Committee on Atomic Energy—February 1959 hearings on the "Development, Growth, and State of the Atomic Energy Industry"—the Commission set forth the following five objectives for its civilian power program:

First: Reduce the cost of nuclear power to levels competitive with power from fossil fuels in high energy cost areas of this country within 10 years.

Second: Assist friendly nations now having high energy costs to achieve competitive levels in about 5 years. This assistance is to be extended mainly through clearly defined programs of cooperation.

Third: Support a continuing long-range program to further reduce the cost of nuclear power in order to increase the economic benefits and extend these benefits to wider areas.

Fourth: Maintain the U.S. position of leadership in the technology of nuclear power for civilian use.

Fifth: Develop breeder-type reactors to make full use of the nuclear energy latent in both uranium and thorium, recognizing that U^{235} alone may not be sufficiently plentiful to meet our needs over the long range.

The first and third objectives are directly applicable to the development of central station powerplants, and they have been used as the principal factors in establishing that part of the program outlined herein which deals with these plants.

The first objective has been further defined as follows:

(*a*) The 10-year period is measured from 1958, when the objective was first stated. This establishes 1968 as the target date for achieving competitive power in high-cost energy areas.

(*b*) It is considered that competitive nuclear power will have been achieved when utility executives can make a decision to build nuclear stations on the basis of economic considerations.

(*c*) High-cost energy areas are considered to be those areas where fossil fuels presently cost 35 cents per million B.t.u. or higher. Conventional power costs in these areas are estimated to be about 7 mills per kilowatt-hour for a 300-mwe., single-unit, fossil-fuel station using fuel costing 35 cents per million B.t.u.—200 p.s.i.a., 1,050° initial/1,000° F. reheat, 1½ inches of mercury back pressure—based on 1959 costs levels, no escalation, 80-percent capacity factor, and 14-percent fixed charges.

No attempt has been made to assign a quantitative definition to the third objective either with regard to time or to the extent of the "wider areas." This objective is the basis for the longer range development program aimed at lowering the cost of nuclear power to a point where it is competitive with fossil fuel in ever-increasing areas of this country.

The other three objectives are more general in nature. With the passage of time and events, conditions relating to two of the objectives have changed substantially.

(*a*) The second objective relates to the achievement of economic nuclear power abroad. When this objective was first stated, it appeared that it could be achieved first in Western Europe in about 5 years. In the last 2 years the increased availability of fossil fuels and the drop in their shipping costs have brought the timetable of achieving economic nuclear power in Europe closer to that of the United States.

(*b*) The fifth objective recognizes the long-term importance of the development of nuclear power systems which can use a major fraction of the uranium and thorium available. At the present time it is not possible to make an accurate prediction of the time when uranium shortages and rising costs associated with such shortages will make the more efficient use of source material a vital factor. However, the ultimate importance of conservation of nuclear fuel dictates a long-range program to develop the breeding potential inherent in both the uranium 238-plutonium and the thorium-uranium 233 fuel cycle.

There has been no change in the fourth objective. The Commission has endeavored and will continue to strive to maintain the United States in a position of leadership in atomic energy use for civilian purposes.

Necessary congressional authorization will, of course, be sought before proceeding with new projects considered in the following concept-by-concept review.

However, before proceeding with this review, I would like to describe with the aid of some charts the specific projects composing our current reactor program.

Turning now to the first chart, discussing, first, light-water-cooled reactors, there is a relatively high probability that light-water-cooled reactors in the reasonably near future can achieve competitive power in the high fuel cost areas of the United States where large single units are practical. In addition, water reactors also offer a longer range potential for being competitive in many other areas of the United States.

Over the next 4 or 5 years, Commission-supported research and development work on water reactors well be aimed primarily at solutions of the problems of nuclear superheat, increased fuel life, decreased fuel costs, simplified fabrication techniques, fuel management, simplified and less costly containment methods, and cheaper materials and methods of construction.

A major effort will be made to develop techniques for economically utilizing plutonium as a fuel material in water reactors.

The water-cooled reactor program is described under three categories: pressurized water, boiling water, and nuclear superheat.

PRESSURIZED WATER REACTORS

The pressurized water reactor concept is technologically well advanced, and is the concept with which we have had the most experience. This experience has demonstrated that pressurized water reactors are safe, dependable, and reasonably easy to control. Capital costs of a 300-mwe. plant of this type, as quoted recently by the manufacturers on a fixed-price basin, when taken in conjunction with fuel guarantees reported to the Commission by utilities and core manufacturers, indicate that the power produced from such a plant initiated now should be competitive over its life in high fuel cost areas of the United States where a plant of this size can be used.

You are familiar with the current pressurized water reactors: Yankee, Indian Point, and Shippingport. We will modify Shippingport to raise its power to 150 electrical megawatts equivalent. Yankee is scheduled to go critical this year, Indian Point next year.

A new small plant was initiated this past year—the 5-megawatt Saxton plant in Pennsylvania. The process heat reactor which we are planning to build in California in cooperation with the Department of the Interior—a reactor to be used to turn sea water into drinking water—is also of this type. This project, as you will recall, was authorized last year.

We have received five proposals in response to our invitation to build a pressurized water reactor to demonstrate the economics of this system for small powerplants. We will shortly select one of these proposals as a basis of negotiation.

Navy and Army work done through the Commission also assists our progress with pressurized water reactors. Indeed, the Navy requirements fathered this concept. The NS *Savannah* should make contributions, and we will gain from the experience of building and operating reactors of this type in other countries—from Selni in Italy, and the Mol plant in Belgium, both engineered and constructed by American companies.

Our written submission reviews what we hope to learn from these activities. In this testimony, I will place emphasis on our future plans.

Chairman ANDERSON. Can you give us any further information on the Shippingport proposal to raise to 150,000 electrical megawatts? Is that still pending? Has Duquesne found some basis of agreement with the Commission?

Mr. MCCONE. No; they have not found a basis to agree with the Commission. It looks like probably the best thing to do at this point

is to build a heat sump. We are proceeding with the engineering and designing of the core, and we intend to ask for modification in that authorization so that the heat sump can be provided.

If you recall, when we met in Albuquerque, you suggested that I appoint a committee to examine into the Shippingport project. This has been done.

The report was received yesterday, and a copy was sent over to you. I don't think it has gotten to you personally as yet, but it was sent to the committee this morning.

(See app. 4, p. 629, for report by ad hoc committee to evaluate the Shippingport project. Also review of pressurized water reactor program by AEC. See also, app. 5, p. 641, for additional correspondence on the Shippingport project.)

Chairman ANDERSON. Now, as to the Selni plant in Italy and the Mol plant in Belgium, you are not entitled to any information out of those experiments; are you?

Mr. FLOBERG. If I may answer that, Mr. Chairman, these are not under any particular arrangements, Senator, except that in the case of the Selni plant, for example, we have a bilateral agreement with Italy, one of our conventional bilateral arrangements.

Chairman ANDERSON. But it does not touch this plant.

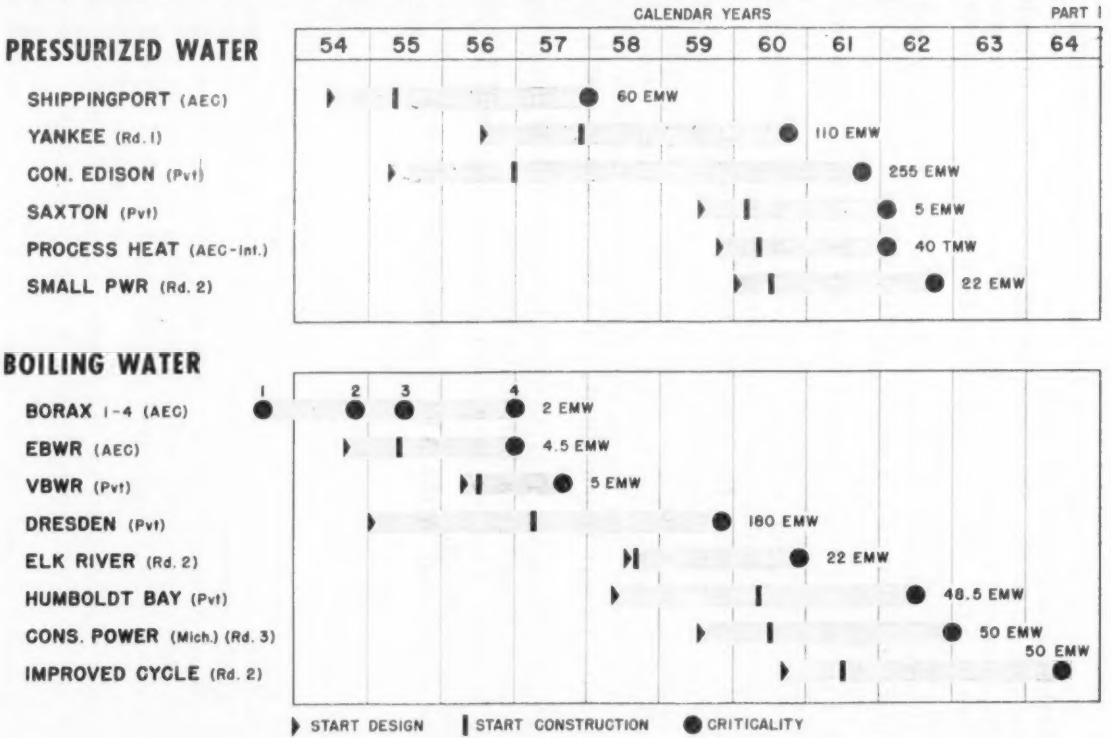
Mr. FLOBERG. This plant is included in the overall framework of the civil bilateral, but there is no particular reference to this plant; no. This plant, incidentally, is moving along on schedule. Some of the fabrication of parts has begun, and the financing has been arranged through the Export-Import Bank, and I believe the project is under control.

Chairman ANDERSON. This chart you have here will be incorporated in the record, if you have a chart that we can use.

Mr. MCCONE. Yes; we have them here and they will be incorporated in the record.

(The charts used in the AEC's presentation follow:)

PROGRESS IN CIVILIAN POWER REACTOR DEVELOPMENT*



*Additional Light Water Reactors in Army, Navy, Maritime and Euratom (Senn) Programs

U.S. ATOMIC ENERGY COMMISSION

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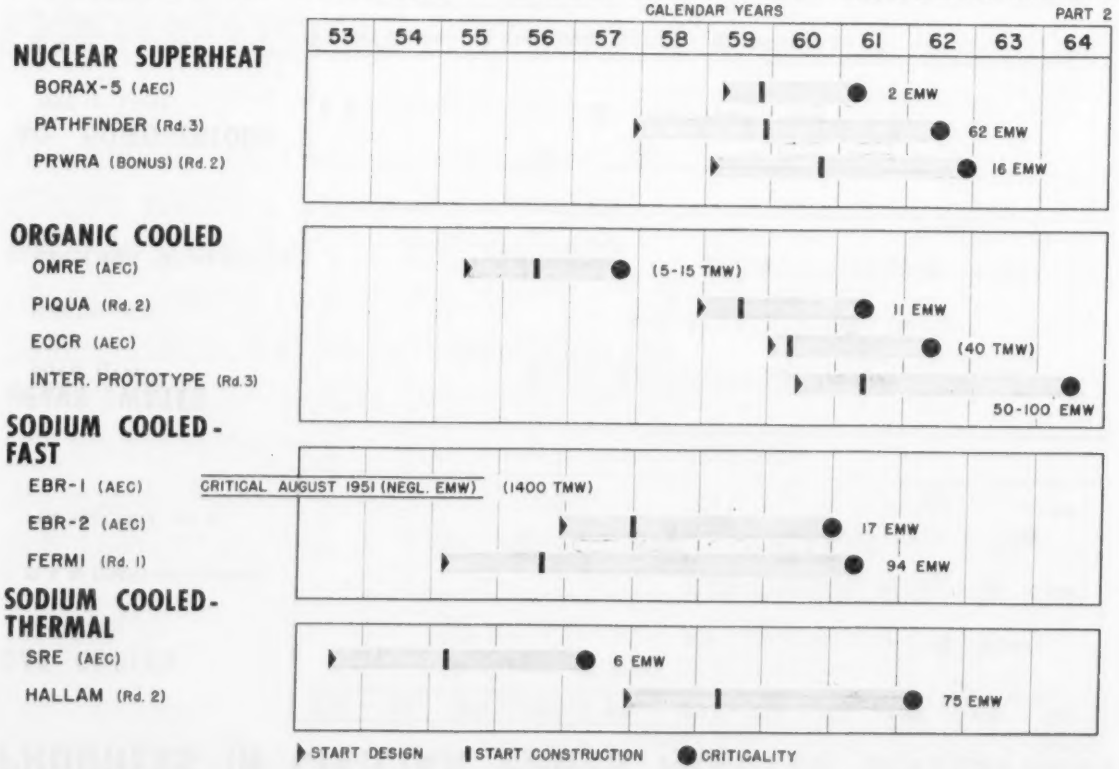
PROGRESS IN CIVILIAN POWER REACTOR DEVELOPMENT

PROGRESS IN CIVILIAN POWER REACTOR DEVELOPMENT

PART 2



U.S. ATOMIC ENERGY COMMISSION

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* Additional Light Water Reactors in Army, Navy, Maritime and Euratom (Senn) Programs

U.S. ATOMIC ENERGY COMMISSION

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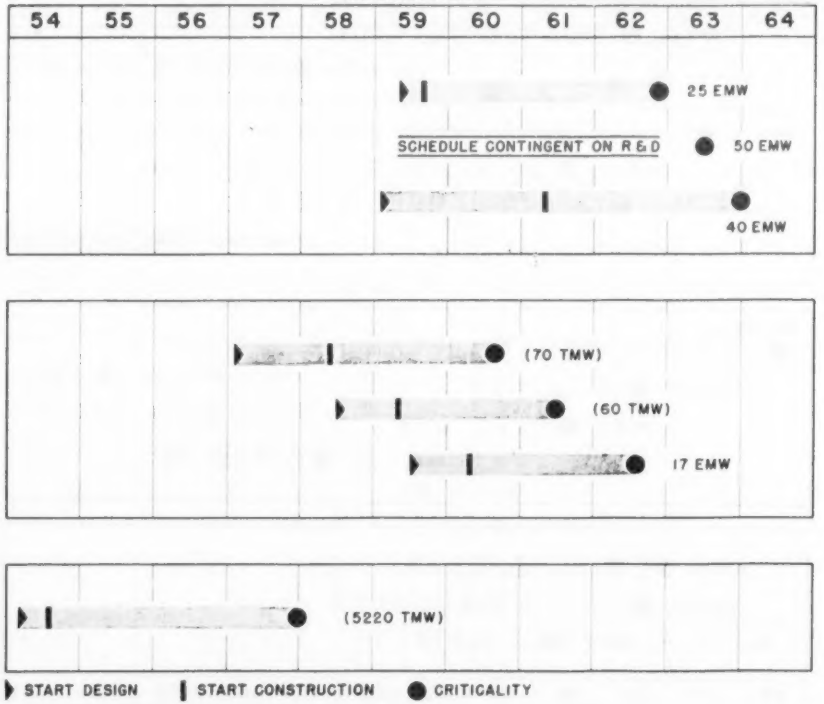
PROGRESS IN CIVILIAN POWER REACTOR DEVELOPMENT*



*ADDITIONAL INFORMATION

GAS COOLED - ENRICHED: Aircraft, Army and Maritime programs
GAS COOLED - Nat U: program
HEAVY WATER: Canadian NPD & CANDU projects

U.S. ATOMIC ENERGY COMMISSION

DRD 607-C 3-60

ESTIMATED DATES FOR INITIATION OF CIVILIAN POWER

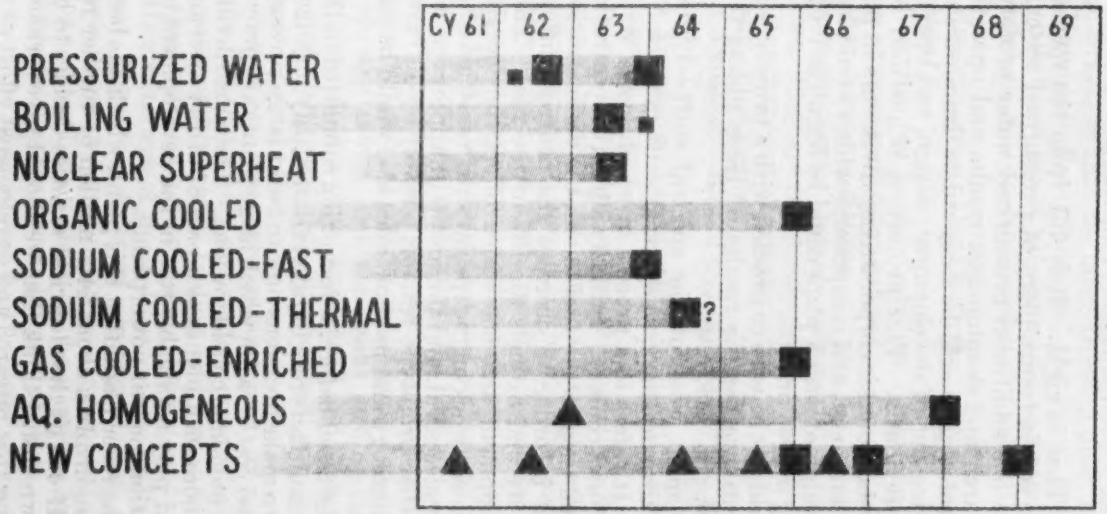
*ADDITIONAL INFORMATION

GAS COOLED - ENRICHED: Aircraft, Army and Marine programs.
GAS COOLED - Not U. program.
HEAVY WATER: Canadian NPD & CANDU projects.

DRD 607-5 3-60

U.S. ATOMIC ENERGY COMMISSION

ESTIMATED DATES FOR INITIATION OF CIVILIAN POWER EXPERIMENTS AND PROTOTYPES* (IDENTIFIED IN PART IV)



U.S. ATOMIC ENERGY COMMISSION

*NO COMMERCIAL PLANTS

DRD 609 2-60

Mr. RAMEY. Would the Shippingport plant in any event go up to its turbine capacity of 100 electrical megawatts?

Mr. MCCONE. No. We plan to keep it at its present level with the first core and carry it up to 150 megawatts with the second core.

Representative PRICE. Mr. Chairman, I think there should be another adjustment on the chart. At Indian Point you show 255,000 megawatts. That is a combination of nuclear power and conventional power.

Mr. MCCONE. That is right. It is 151 from the nuclear.

With reference to the future plans of pressurized water, it is probable that at least one additional pressurized water prototype will be justified by research and development results and operating experience. Such a prototype would be designed to demonstrate improved technology growing out of development, design, and operation of the reactors listed previously. This prototype, if justified by developments and analysis, would incorporate improvements in plant design, construction, containment, and components which would lead to lower power costs. Design of such a plant could be begun in 1962, with construction starting in 1963 or 1964.

We feel it would not be wise to proceed with a prototype in the pressurized water until we get the results of these plants that are just coming onstream.

If the development work on the spectral shift—I would like to explain, Mr. Chairman, that this spectral shift is not a Notre Dame backfield term. It refers to a process in which heavy water is added to the light water as a coolant. Initially a high concentration of heavy water is used, and then as the fuel burns, the concentration of heavy water is reduced in order to decrease the neutron diffusion, which increases reactivity and extends the life of the fuel. This is a relatively new development and one which offers considerable promise.

If the development work on the special shift variation of pressurized water systems is successful, and the idea still appears promising, construction of another prototype reactor, possibly 50–100 mwe., to demonstrate this technology and its economics also would be started in the early 1960's.

As has been discussed before, information submitted to the Commission by reactor manufacturers indicates that utility managements may be in a position to make decisions now to build large pressurized water plants in high fuel cost areas in which large plants are practical, basing their decision on economic considerations. The construction and operation of one or more such plants as a part of utility systems located in such areas would play a valuable role in the development of economic large central station nuclear powerplants.

I might, for the record, add that this plant, which has been proposed by Westinghouse, involves about $4½ million of further research and development. If one of the electrical utilities decides to build such a plant at their own cost, I think that we should give serious consideration to supporting that research and development effort as a justifiable expense in advancing the technology.

The studies which are currently being made with respect to the feasibility of reactor-generated power in remote locations, together with the technical information developed in Army and Navy reactor programs, may indicate the desirability of initiating in 1962 a small power reactor prototype—20 to 30 mwe.—at some installation which would offer a test of reliability under varying conditions.

BOILING WATER REACTOR PROGRAM

The technical feasibility of boiling water reactors has been successfully demonstrated by the Borax experiments at the National Reactor Testing Station in Idaho, the experimental boiling water reactor at Argonne National Laboratory, and the Vallecitos boiling water reactor in California. Based on currently available information, there is every reason to believe that the large Dresden plant now in its startup phase, the Humboldt Bay plant, and the Rural Cooperative Power Association Elk River plant, all using boiling water reactors of varying size and design, will operate successfully and will furnish valuable information.

Senator HICKENLOOPER. Mr. Chairman, may I ask Chairman McCone a question?

The plants which you have referred to, could you call those plants in any degree economically competitive?

Mr. MCCONE. No; none of them.

Senator HICKENLOOPER. They are very costly.

Mr. MCCONE. They are very costly; yes.

Senator HICKENLOOPER. Very costly?

Mr. MCCONE. That's right.

Chairman ANDERSON. Would you say that of the Dresden plant?

Mr. MCCONE. Yes.

Chairman ANDERSON. Very costly. It is within a mill of what they had hoped to get.

Mr. MCCONE. I think they are getting exactly what they hoped to get. If you will recall—I believe I am correct—that the first $30 million of the cost was to be put up by the Commonwealth Edison, and that with the fuel cost would result in something on the order of 8-mill power. But there was another $15 million on top of that that was put up by the syndicate and that was written off for research and development. There is a possibility that GE put some in. If you put all of that into Dresden, you would get to a plant in which the power to amortize the total cost would be quite expensive.

Senator HICKENLOOPER. You can make any of these plants competitive if you just took a paper and pencil and drew a line through a lot of the cost that went into it and just disregarded it in the accounting.

Mr. MCCONE. Yes. The encouraging part of this discouraging business is the fact that we are getting to a point where we are getting in the ball park at least with boiling and pressurized water. The decrease in the plant cost has been quite dramatic.

Senator HICKENLOOPER. I don't dispute that. I think we are making progress. There was a lot of propaganda put out a few years ago that these plants were going to be very dependable.

Mr. MCCONE. Yes; I know there has been quite a lot of propaganda and there have been some great disappointments. I would be less than frank with you if I did not say that what gives me confidence in the current situation is the fact that major corporations in the business will sign on the dotted line on a guaranteed plant cost and a guaranteed fuel burnup, and this insures the cost of the power.

Senator HICKENLOOPER. That is on the newer plants.

Mr. MCCONE. On the newer plants; yes.

Chairman ANDERSON. I was just going to say the propaganda was not all on one side. I remember Mr. Oakes' testimony in 1955, and I

would be glad to read it. He wanted to build a plant and didn't want a dollar's worth of help from the Federal Government of any kind. He was ready to go right now. I don't believe that plant has yet been constructed.

Senator HICKENLOOPER. I was not insinuating it was Government propaganda. I just said there was propaganda generally put out several years ago that these plants were going to be economically sound. A lot of people didn't believe that they would.

Chairman ANDERSON. I only feel this way about the Dresden plant: I was very happy with Willis Gale and his company in going ahead with it. It was a brave venture and it may not be extremely competitive in the beginning, but I think it is going to lead to something that is competitive, and I am very happy that the plant was built even if it costs a mill more than they pay for conventional power and possibly 2 mills.

I still think they did a fine job.

Mr. MCCONE. I think they went into that with their eyes open. I think they made a great contribution. I think had they not done what they did, had other companies and the Government not done what was done, we would not see the progress we see today.

Representative PRICE. When does it appear now that the Dresden plant will be in operation?

Mr. MCCONE. The contract between the Commonwealth Edison and General Electric calls for the plant to be in operation, fully tested, and demonstrating its full capacity, on or before December 4, 1960.

Representative PRICE. When it goes into full operation at the anticipated 180,000 kilowatts, then it will be the world's largest single reactor producing electrical energy; is that correct? I mean single reactor.

Chairman ANDERSON. I think we ought to explain; Mr. Price is from Illinois and he is trying to get a small plug as to where the largest one is going to be.

Mr. MCCONE. I think that is true. I hesitated——

Representative PRICE. There are other nuclear powerplants that produce more electricity, but they have two or three or four reactors.

Mr. MCCONE. The large British plants have several units. I don't know any one unit gets up to 180 megawatts.

Representative PRICE. I at least don't recall any. There has been no testimony before our committee that there is a single reactor in existence today that produces 180,000 kilowatts electrical energy.

Mr. MCCONE. I think that is true. I would have to check these more recent British plants, although it is true that this plant is, or will soon be, in operation, and the others are in construction.

Representative PRICE. Most of the estimates we have had from British has been on the total power station.

Mr. MCCONE. That is right.

Representative PRICE. Sometimes there are two and three and four reactors.

Mr. MCCONE. Yes.

We are modifying the EBWR to raise its thermal power to 100 megawatts—five times its design capacity. The Elk River small power reactor is scheduled for criticality this year. Dresden went critical last October. They have run into some problems, but still expect to reach full power this year. I might say that the problems have been satisfactorily answered. At least we feel so at the present time.

The General Electric Vallecitos plant, which contributed to Dresden, is being modified; Pacific Gas & Electric's Humboldt Bay plant is scheduled to go critical in 1962. We are negotiating with Consumers Power Co. on the high-density core 50-megawatt plant it has planned for Michigan. We have issued invitations for proposals on a simplified 50-megawatt prototype and hope to start construction this year or early next. This reactor will incorporate in its design such features as improved control methods, simplified containment, and increased output of power per unit of waterflow. Primarily a prototype for large reactors, this project will develop engineering improvements applicable, in general, to small reactors. Also, we will gain knowledge and experience from the Senn plant in Italy.

FUTURE PLANS

Aside from developments involving nuclear superheat which are described elsewhere in this report, most of the currently foreseen developments in boiling water technology probably will be demonstrated with these reactors. When operating experience is available from these reactors in 1963 or 1964, it will be possible to determine what, if any, additional experimental or prototype reactors are needed to achieve competitive power in large boiling water reactors. Until such a determination is made, no further construction of large boiling water experimental or prototype reactors is contemplated by the Commission.

In the small reactor field, results from Elk River, Humboldt Bay, and the simplified reactor project discussed earlier may indicate in 1963 or 1964 the need to initiate construction of a small—20–30 mwe.—prototype.

As in the case of pressurized water reactors, we have been advised by a manufacturer that a 300-mwe. boiling water plant can be built now on a fixed-price basis, with certain fuel cost guarantees, which may produce power competitive with conventional power over the life of the plant in certain high-cost fuel areas of the United States. It is the Commission's opinion that the construction of one or more boiling water plants by utility companies in high-cost areas where plants of this size may be practical would make a significant contribution to the development of economic power.

Chairman ANDERSON. Mr. Chairman, I am happy to have that observation. You may recall on November 9 last year I sent you a letter in suggesting that in developing the committee's proposals, the role of large-scale prototypes for commercial-size plants should be carefully considered.

We found that it is somewhat difficult to write a formula for taking a share of the construction costs. It gets into a lot of complications that makes it hard to write legislation.

Therefore, your suggestion a while ago that there might be some research and development appeals at least to me, and I hope it appeals to other members of the committee.

I do hope that there is a continuing pushing on your part which I know has existed to try to get some of these large prototype and commercial sized plants constructed so we can learn from them.

I am very happy to have this statement in the report.

(Correspondence relating to the AEC's proposed civilian atomic power program follows:)

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
Washington, D.C., November 9, 1959.

Mr. JOHN A. MCCONE,
Chairman, U.S. Atomic Energy Commission,
Washington, D.C.

DEAR MR. MCCONE: This will acknowledge your recent letter informing the Joint Committee of the appointment of an ad hoc committee, similar to last year's committee, to consider the Commission's proposed civilian atomic power program. Copies of parts I and II of the Commission's Atomic Power Program Study—the so-called 10-year program—have also been received by the committee staff. It is recognized that parts I and II are preliminary at this time.

As you know, the Joint Committee has for many years been in favor of the Commission undertaking long-term plans and programs for the civilian atomic power program. In this letter I would like to bring to your attention certain points which the committee has considered of importance. I believe it is important that the Commission and its staff and the ad hoc committee consider these points during the formulation of its program, rather than after policies and projects are completely crystalized:

(1) I believe it desirable that previous proposed programs be carefully considered, particularly the Joint Committee staff study and the Edison Institute Task Force Report.

(2) In developing the Commission's proposals, the role of large-scale prototypes and commercial-size plants should be carefully considered. As you will recall, last year smaller prototypes were emphasized. We are pleased to note that part II of your study does apparently consider larger scale plants as a part of the program.

(3) Careful consideration should be given to the level of support to be given to a 10-year program by the Government. We are pleased to note that part II of your study does give total cost estimates for the program, which is a start in this direction. You will recall that both the Joint Committee staff study and the Commission's ad hoc committee of last year emphasized that increased financial support for the civilian atomic power program was necessary.

(4) Careful consideration must also be given to the proposed schedule of the program. This schedule projected in part II of the study was acknowledged by a Commission official to be susceptible to being moved up if considered necessary.

(5) In considering the cost of the program and the need for moving ahead, care must be taken not to cut out promising approaches for atomic power development for budgetary reasons. In other words, the selection of projects for curtailment or discontinuance must be primarily on technical grounds. It would be unfortunate at this very early stage of atomic power technology if a particular concept were dropped because of the vagaries of the Government's budget situation.

(6) The relative role and forms of non-Federal and Federal financial support for the program should be considered. As you will recall, the subject of construction grants discussed during fiscal year 1960 authorization hearings was deferred pending further study. I suggest that this form of assistance be considered and developed more fully along with Government construction and other forms of assistance in the nuclear power program.

I hope that before the Commission crystallizes its program, it will be possible for the Commission or its staff to informally discuss the general program level and schedule with Joint Committee members or staff.

Sincerely yours,

CLINTON P. ANDERSON, *Chairman.*

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., December 1, 1959.

Hon. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Congress of the United States.

DEAR CLINT: Thank you for your letter of November 9, 1959, suggesting certain points for consideration during the formulation of our civilian atomic

power program. I can assure you that your comments are being given very careful consideration.

I believe that the basic objectives and philosophy of the civilian nuclear power program are well established as the result of discussions during the past year or 2, and that only refinements of interpretation are likely to be necessary. In view of this, our recent efforts have been directed primarily at technical evaluations and analysis of economic potentials of various reactor systems as they may develop in the foreseeable future. No arbitrary levels of financial support from the Government are being imposed, rather we are trying to plan a logical technical development program which will offer high probability of achieving program objectives and we are trying to estimate the cost of carrying out that program. It is, of course, impossible to guarantee that results of research and development will be as expected. Therefore one cannot guarantee that any particular program involving extensive research and development will achieve its objectives.

The planning naturally is being carried out with full recognition of the need to be selective in the lines of development to be pursued and the prototype reactors to be built in order to avoid unnecessary expenses or expenses of questionable value under the current technological situation.

Certainly we will be pleased to exchange views with the Joint Committee members or staff as our own thoughts develop. I understand that a preliminary meeting between representatives of our respective staffs has been scheduled for December 3, 1959.

Sincerely yours,

(S) JOHN, *Chairman.*

Mr. MCCONE. Thank you.

Turning to nuclear superheat, nuclear superheat can be applied to both direct and indirect cycle boiling water reactors, and to indirect-cycle pressurized water reactors. In direct-cycle boiling water reactors, nuclear superheat may be integral. In indirect-cycle reactors, whether boiling or pressurized, what is essentially a separate steam-cooled reactor would be required to obtain nuclear superheat.

Nuclear superheat would make possible production of steam at temperatures and pressures used in modern conventional powerplants at high efficiency. Development work and design studies have been underway for some time, concentrating chiefly on the superheat fuel element. Data from these programs are applicable to both direct- and indirect-cycle reactors. Design studies and evaluations have been made on integral superheat systems, and soon will be initiated on separate superheat systems. I will go into a little more detail about our current work on superheat.

(*a*) The fifth boiling reactor experiment—Borax 5—is under construction at the National Reactor Testing Station and is scheduled to become critical in March of 1961. The reactor will be operated initially with a limited number of test channels producing superheated steam and will be converted gradually into an integral nuclear superheat reactor. Flexibility designed into the system will permit investigations of nuclear stability problems associated with various fuel and coolant arrangements.

(*b*) The Northern States Power 62-mwe. plant near Sioux Falls, S. Dak., is under construction and is scheduled for criticality in 1962. This reactor will provide test and operating data on a high-density, integral nuclear superheat core. Development work leading to reduction in the enrichment of fuel in the superheat section of the core will continue.

(*c*) A contract has been signed with the Puerto Rico Water Resources Authority for construction of a 16-mwe. boiling nuclear superheat reactor—bonus. This reactor will provide information on the practicality of an integral nuclear superheat design for small

reactors, and will assist in the evaluation of nuclear superheat in large plants. The target date for criticality is early 1963.

This, Mr. Chairman, is the plant that was studied by Dr. Zinn's organization. If you will recall, I told you at our hearings last year that his report was due in October or November. It was submitted on time. The study found the project offered a very great deal of interest, so we proceeded promptly with a direct negotiation with the Puerto Rican Water Board and some of the problems that concerned us, and I know the problems were satisfactorily ironed out by negotiation. I think this is a good project to have underway.

Chairman ANDERSON. May I say, Mr. Chairman, I know there are some members of the committee—and I am one of them—that are very happy that this arrangement went through. Doctor Zinn had a chance to work out his theory and complete his work, and I am very happy that it is underway. I think it is likely to be very significant in its results.

Mr. MCCONE. If the technical and economic information obtained from these projects confirms the prediction that nuclear superheat can substantially lower power costs in boiling water reactors, a 100-mwe. prototype would probably be required to exploit the full potential of the system. Such a prototype, if justified, probably would be initiated in 1963.

If the program outlined above is followed and it proves successful, it is anticipated that by 1968–69 sufficient technical and economic information will be available to permit utilities in certain areas of the country to decide on economic grounds, to construct a large—300 mwe.—integral superheat plant.

ORGANIC COOLED REACTOR PROGRAM

There is relatively high probability that organic cooled reactors can achieve competitive power in high fuel cost areas of the United States by the middle 1960's and in the longer range over many other areas. Because of the encouraging experience in operation of the organic-moderated reactor experiment and in other research and development work already done, because of the relative simplicity of the system, and because of the direct applicability of much of the technology developed in water reactor programs, it is believed that this concept can achieve its early potential with less research and development and construction of experimental and prototype plants than are required for other reactor concepts.

Organic-cooled reactors operate at higher temperatures and lower pressures than water reactors, and have no major corrosion problems. These characteristics make for low capital cost plants. However, high costs for replacing decomposed coolant are an economic disadvantage. Organic coolants also have poor heat transfer characteristics and require fuel elements with extended surfaces and high conductivity cladding. Since a longer lived fuel must be developed, research and development work at present is primarily on aluminium-aluminum oxide claddings for uranium oxide and uranium alloy fuel materials. Research and development work also is directed toward lower organic makeup costs and improving organic fluid flow and heat transfer characteristics.

In the longer range, the research and development program will be directed toward utilizing plutonium as a fuel in organic reactors.

I would like to say, Mr. Chairman, that these problems of perfecting the fuel element of the organic-moderated reactor and also improving the qualities of the organic coolant itself are not simple problems. While we have great hope that the research going on now will demonstrate that fuel elements can be developed which will be dependable, the future of this concept depends on the success of this research and development work which is now being carried on.

Our development work for organic-cooled reactors includes two experimental reactors and two prototypes. We will use the organic-moderated experiment for further tests, and hope to start building this year the larger and more flexible experimental organic-cooled reactor. It is scheduled to go critical in 1963.

The plant we are building in cooperation with the city of Piqua, Ohio, is important as a prototype for small power installations. Criticality is scheduled for next year. Invitations are out for proposals to build a 50- to 100-electrical megawatt plant to go critical in 1964. Proposals are due in by next April 2. This reactor is primarily a prototype for large-scale power reactors, but the basic fuel elements information it develops will be important for process heat and small power reactors.

Here again much of the advantages of this particular prototype are dependent upon the success of the research and development of the fuel element. I feel that unless we have a breakthrough and unless the optimism of those who are carrying on the work is met, it may be that this subject will have to be held up for a little while because it will be unwise to proceed with it unless we can get a proper fuel element.

Assuming success in operation of the 50–100-mwe. prototype and in other research and development, it is anticipated that by 1965 or 1966 sufficient information will be available to permit a utility to decide, on economic grounds, to construct a 300-mwe. organic-cooled reactor in a high fuel cost area and later in wider areas.

In the middle 1960's, continuing research and development, if successful, should indicate further improvements possible in organic-cooled reactors. A 50–100-mwe. prototype may be justified to demonstrate these features.

Turning now to the sodium-cooled reactors: Sodium-cooled reactors appear to have a high potential for achieving competitive power in large areas of the United States in the late 1960's or early 1970's.

Sodium has many attractive features as a reactor coolant. It is liquid at relatively low temperatures, has a very high boiling point, reasonably low neutron absorption cross section, and excellent heat transfer and heat transport qualities. These characteristics make possible very high steam cycle efficiencies. Because of the negligible pressure required for sodium systems, very large sized (500 mwe. and larger) reactors are practical. This is an advantage since unit power costs generally decline with increased plant size. The Experimental Breeder Reactor No. 1, the sodium reactor experiment, and the submarine *Seawolf* and its prototype reactor have demonstrated that sodium-cooled reactors can be operated safely. However, there still are problems with fuel elements and components which must be solved before these systems can achieve their full potential.

Since liquid sodium is not in itself a moderator, systems which use this material as a coolant can operate over a wide neutron energy

spectrum, depending upon the presence and characteristics of moderating material. In fast and possibly in epithermal systems, sodium-cooled reactors are capable of breeding. Sodium-cooled reactor systems can operate with uranium 238-plutonium fuel systems or with thorium-uranium 233 systems.

The Commission's program for sodium-cooled reactors is presented below under two headings—fast reactors and thermal reactors.

SODIUM-COOLED FAST REACTORS

Most of the technical and economic advantages which are inherent in the use of sodium as a reactor coolant apply to fast systems. They have an additional advantage in their ability to achieve high conversion ratios or to breed.

The research and development program for fast or epithermal liquid metal-cooled reactor systems is long range in nature and is expected to yield significant results in the late 1960's. In its initial stages, it will concentrate on the development of a satisfactory, long-life, high-burnup fuel material; on the utilization of plutonium and uranium 233 as fuels and of uranium and thorium as fertile materials; on the development of reliable and less expensive sodium components; and on the development of efficient and rapid fuel recycle methods.

To help accomplish these objectives, two prototype reactors are under construction, both scheduled to go critical this year: The Government's second experimental breeder reactor and the Enrico Fermi atomic powerplant. We are continuing to operate the first experimental breeder, and the next step is to install a plutonium cermet core. Aircraft experiments are expected to make useful contributions through their work with a number of liquid metal-cooled units. Information on British and French fast reactors will supplement our own efforts.

Chairman ANDERSON. Mr. Ramey has a question.

Mr. RAMEY. Does not the success of your fast breeder work depend upon the development of this cermet type of fuel element, and is that not in its veritable infancy, you might say, of development?

Dr. PITTMAN. I think the use of the word "success" is going probably a little too far, Mr. Ramey. I think what we would say is that the economic potential of the fast breeder systems cannot be developed unless we develop a fuel element capable of a much longer life. This seems to be the cermet element. The development of this element is in its infancy, as you indicate, but there is every reason to believe that we can develop an adequate cermet element.

Mr. RAMEY. In comparing this approach with your sodium graphite type, or even other concepts, just offhand it seems that the fast breeder is as difficult as some of the others.

Dr. PITTMAN. The achievement of the economic potential of the sodium thermal system is also dependent upon the development of a much better fuel element than the ones we have now, such an element as uranium carbide or possibly the cermet developments. And the development of either the fast system or the thermal system would be equally applicable to either.

Mr. MCCONE. Regarding the future of the fast reactor, a 100-mwe. prototype sodium-cooled fast or epithermal reactor will be constructed if the results from existing or planned reactors provide a basis for

improved design. Two years of operating experience on these plants should be available before starting the new prototype. Detailed design and construction could start in 1963 or 1964. The primary purpose of this reactor will be to incorporate the improvements in design arising out of the operation of prior plants, and to demonstrate a plutonium-fueled core optimized for lowest power costs.

With the successful completion and operation of the above prototype and data from other plants, it is believed that, by the late 1960's, enough information will be available to permit utilities to decide, on economic grounds, to construct large sodium-cooled fast breeder plants in many areas.

SODIUM-COOLED THERMAL REACTORS

Sodium-cooled thermal reactors have the potential of achieving economic power in high fuel cost areas of the United States. These reactors can be operated at high temperatures and low pressures. However, to obtain full benefit from these characteristics, a greatly improved fuel element must be developed: one capable of long life in the high-temperature environment. For this reason it is unlikely that this potential can be achieved at an early date.

Sodium-cooled fast reactors offer most of the advantages of the sodium-cooled thermal systems. In addition, they offer the possibility of lower fuel costs through breeding. Consequently, work on thermal, sodium-cooled reactors would not be expanded until we can evaluate operating results from the 75-electrical-megawatt Hallam reactor which is scheduled for criticality in 1962. Operation of the sodium reactor experiment will support this concept. Research and development for sodium-cooled thermal systems will concentrate on uranium carbide fuel development and on major improvements in the design, efficiency, and performance of the sodium components. In carrying out this program, full consideration will be given to the points of similarity between thermal and fast systems, and the work will be directed in such a way as to achieve maximum benefit to both.

FUTURE PLANS

If evaluation of Hallam operation shows a more favorable potential than had been foreseen for this concept—and that would be dependent upon the development of an improved fuel element—consideration will be given to constructing experimental or prototype plants to develop improvements. Additional facilities will not be considered, however, until operating experience is available and therefore would not be initiated before 1963 or 1964.

In summary, Mr. Chairman, in this sodium field, we are building the Hallam plant with a thermal cycle, and that will be completed in 1962. There is the fast breeder No. 2 and the Fermi plant which will be completed at the end of this year. We have to look forward to results from those plants before we make our decision as to what further steps to take. The minute that we can get results from the operations, I think we could safely move forward in additional plants to demonstrate advanced technology. These plants are considerably behind the pressurized and boiling water plants which I mentioned earlier.

ENRICHED URANIUM GAS-COOLED REACTOR PROGRAM

Enriched uranium gas-cooled reactors have the potential of producing superheated steam of the quality currently in use in large conventional central station powerplants with the resulting high efficiency. Gas-cooled reactors can operate at low pressure and therefore can be built in very large sizes.

The Commission has two approaches to the gas-cooled reactors program, exemplified by the 22.3 mwe. net (or 25 mwe. gross) Experimental Gas-Cooled Reactor (EGCR) being built at Oak Ridge and scheduled for criticality in 1962 and the Philadelphia Electric Co.'s High Temperature Gas-Cooled Reactor (HTGR), scheduled for criticality in 1963—a 40-mwe. plant; 28.5 mwe. with metal-clad fuel. The HTGR will use graphite-clad fuel consisting of fully enriched uranium carbide and thorium carbide dispersed in graphite. The EGCR, the Oak Ridge plant, will utilize stainless-steel-clad, slightly enriched uranium dioxide fuel. In both reactors, heat is removed from the fuel by a helium coolant and transmitted to a heat exchanger where steam is formed to drive the turbine. The graphite-clad system shows greater economic potential than the metal-clad system, but presents more difficult development problems.

Representative HOSMER. I was just wondering: This 28.5 mwe. in the high-temperature reactor—is that a heterogeneous core? Is it the initial small-sized core?

Mr. MCCONE. No; it is the metal clad.

Representative HOSMER. Of a smaller size, the initial core?

Mr. MCCONE. The initial core, the first core, will be metal clad.

Representative HOSMER. They still plan to make that metal-clad core?

Mr. MCCONE. They still plan to make the metal-clad core.

Chairman ANDERSON. And the other would be the second?

Mr. MCCONE. The homogeneous core; yes.

Chairman ANDERSON. Now, you refer to gas-cooled reactor as experimental. And in the law we kept referring to the prototype. There was some suggestion that the prototype be dropped. You have not given the prototype up; have you?

Mr. MCCONE. No; we have not. As you know, we are putting in a full-size 25-megawatt generator, which we had at Oak Ridge, on that plant, and it will generate power, which we will consume. So it will be a prototype, inasmuch as it will feed power into our Oak Ridge grid.

Chairman ANDERSON. I think many of us are glad to see the two approaches go ahead. If the Oak Ridge one works, fine. If the other one works, we are probably many steps ahead of certain other areas of the earth, and it will be a very fine thing.

Mr. MCCONE. Well, there has been a great deal of discussion between the engineers as to which of these two offers the greatest potential. I do not think this horserace is settled by any manner of means.

Chairman ANDERSON. That is why I am glad we are building them both. We may find the thing we did not think would be the better one will prove to be the better one. It is a good thing that we are building them both.

Mr. McCone. Present and immediately foreseeable research and development is concerned primarily with design and construction of the EGCR and HTGR. Their construction and operation will make possible a more comprehensive evaluation of the potential of the gas-cooled reactor system. The program also will include investigations of fuel and cladding materials suitable for high burnup at fuel surface temperatures of 1,700° F. and higher and of alternate coolants. A number of military reactors—aircraft and Army projects—will continue to contribute to the gas-cooled program, and development work on other reactors for special purposes, such as maritime propulsion, will provide important information. We are receiving much assistance through our cooperative work with the United Kingdom.

In this connection, we have worked out two exchange agreements with the United Kingdom in these two areas, and while all of the details have not been finally settled, it looks like they will be much broader than the ones we discussed last year.

Chairman Anderson. Actually, Mr. Chairman, the Turret project will also contribute to this, will it not?

Mr. McCone. Yes, indeed.

Chairman Anderson. You discuss that later on, but it is of value in this program.

Mr. McCone. Yes; that is right.

Based upon the successful operation of the EGCR and the HTGR, a prototype to demonstrate advanced features will be initiated. An evaluation will determine the choice between the EGCR and the HTGR approaches.

Or it might be, I might add, that both approaches might prove sound.

It is expected that such a 100-mwe. prototype could be initiated in the middle 1969's.

It is believed that after operating experience is gained from the programed reactors, sufficient information will be available to permit utilities to decide, on economic grounds, to construct in high fuel cost areas a 300- to 500-mwe. gas-cooled reactor using enriched fuel.

Now, Mr. Chairman, I would like to turn to the heavy water reactor program.

Heavy-water-moderated natural uranium fueled reactors have a number of advantages. They eliminate dependence upon diffusion plants in the fuel cycle. They have high neutron economy. They require relatively small quantities of uranium ore per unit of power produced. On the other hand, these reactors are physically large with consequent high capital costs. The reactivity lifetime of the natural uranium fuel is more limited than that of enriched uranium fuel.

Several heavy-water-moderated reactors, are planned or are under construction in the United States. They include prototypes using enriched fuel at this stage, but capable in larger sizes of operation on natural uranium. Also, the Canadians are planning construction of both a 20-mwe. prototype, known as the Nuclear Power Demonstration Plant, or NPD, and a 200-mwe. natural uranium heavy-water-moderated plant, the Candu. These plants are scheduled for criticality in 1961 and 1964, respectively. Negotiations are currently underway with the Canadians looking toward an expanded program

for close cooperation in the development of heavy water reactors. Cooperation under this agreement will be mutually beneficial and, in addition, will serve to assist the Commission and U.S. industry in determining the future role of heavy water reactors in this country.

I would like to add that under this agreement now being negotiated, we would support the Canadian effort by experimental research and development work performed in our own facilities, and we would also cooperate in all phases of engineering and development. The agreement would provide that we would obtain for use by the Commission, or by its contractors, all engineering information and detailed plant designs and all drawings and all rights to developments and patents as would accrue to us if we proceeded with the construction of a plant in the United States.

This agreement will be placed before your committee as soon as the details are finally worked out with the Canadians. We have substantial agreement with them now.

Senator HICKENLOOPER. Mr. Chairman, may I ask Mr. McCone a question at this point?

With this Canadian construction going on with our cooperation, it would seem to me that it would eliminate all necessity for us to build a plant of our own in the United States along this line. Would you say that that is true, or partly true?

Mr. MCCONE. It would eliminate the necessity of us initiating a plant at the present time. We would proceed to complete the construction of the plants which are now in our program and would utilize them and the developmental work and research work, which will be our contribution to the large plant built by the Canadians. We would not feel it would be necessary to initiate a large plant ourselves.

Senator HICKENLOOPER. In other words, we can learn everything from the Canadian plant with this cooperative agreement that we could learn from our own.

Mr. MCCONE. We think so. There will be some costs to us for this research and development work.

Senator HICKENLOOPER. I understand.

Mr. MCCONE. And authority will be sought from your committee for us to engage in that work.

Senator HICKENLOOPER. Thank you.

Representative HOSMER. What is the order of magnitude of that cost, if you have an idea?

Mr. MCCONE. Oh, it is in the order of $5 to $8 million of direct costs, which would be a direct contribution to the Canadian project, in addition to a considerable amount of research that we carry on in this field.

Representative HOSMER. You mean direct cost in money and not cost of work in our laboratories?

Mr. MCCONE. No, no. This would be direct cost of work in our laboratories, which would be done specifically in support of that project.

Representative HOSMER. Over what period of time?

Mr. MCCONE. Over a 4-year period of time.

Chairman ANDERSON. And, in addition, you do some ordinary research work that may be applicable?

Mr. McCone. Oh, yes.

Chairman Anderson. This would be directly tied in?

Mr. McCone. Yes; it would be directly tied in. This would be of the nature of the type of research work that is done in support of a third-round program, similar to that, and for that reason it is something that we would have to discuss with you and secure your special authorization for.

The U.S. research and development program will be directed toward those problems which are critical to the evaluation of heavy-water-moderated systems. To the fullest extent possible, it will use pertinent information being developed in other programs and in other countries. The critical problems are those associated with reactivity limitations on fuel lifetime (including fuel management techniques for extending these limits), minimizing loss of heavy water, and techniques for fabricating components of pressure tube or pressure tank systems. One difficult design objective is to obtain the high coolant temperature needed for high thermal efficiency while maintaining the cool moderator necessary for long fuel-reactivity lifetime. The research and development program and cooperation with other countries will be planned so that the combined results will provide a sound basis for evaluation of this class of reactors, including designs which use coolants other than heavy water (e.g., organic and gas).

The four projects in this country all using enriched fuel include the heavy water components test reactor scheduled for criticality in 1961 at the Savannah River plant. Research and development on a cooperative basis in support of the 50-mwe. reactor of the East Central and Florida West Coast Nuclear Groups will continue, looking toward an early evaluation of the project.

It is expected that a decision will be made on this project this fall.

You will recall, Mr. Chairman, that the arrangement made with this particular power group is that if the research and development work which is being carried on jointly now by the company and the Commission shows certain unfavorable results, then the utility is not obligated to proceed. We hope that the final reports will be in in the relatively near future and we can reach a decision on this.

If built, the reactor is scheduled for completion in 1963. A heavy-water moderated and cooled pressure tube reactor of 17-mwe. capacity is being designed and is scheduled for criticality in 1962 in accordance with a contract between the Commission and the Carolinas-Virginia Nuclear Power Associates, Inc. The plutonium recycle test reactor, scheduled for criticality in 1960, uses heavy water as a coolant and moderator, and incorporates a pressure tube design. It is an important source of additional information and technology.

FUTURE PLANS

When operating and cost data are available from the United States and Canadian heavy water reactors, there should be sufficient information to determine whether or not construction of a large heavy water reactor is economically justified in high fuel cost areas of this country. We believe such an evaluation can be made by 1966 or 1967.

AQUEOUS HOMOGENEOUS REACTOR PROGRAM

The aqueous homogeneous reactor offers many advantages for production of power since it operates with a solution fuel, incorporates continuous fission product removal, and is largely self-regulating due to its large negative temperature coefficient. It further offers the possibility of breeding when operated on a thorium-uranium 233 fuel cycle. Major technical problems are associated with the corrosive nature of the fuel, stability of the fuel solution under irradiation, the maintenance problem associated with the radioactive primary loop, and the limited operating temperatures with the attendant low steam cycle efficiencies.

It is still too early to determine whether the simplicity of the fuel cycle and potential breeding will be more than offset by technical complexities and temperature limitations. Because of the special advantages, research and development will be continued on the technical problems on a long-range basis.

Chairman ANDERSON. Mr. Chairman, you had another little incident down there and developed a second hole in that. Does that change your plans in any way?

Mr. MCCONE. No; it does not. We have not evaluated that. We have had under discussion for several weeks the question of proceeding with another reactor experiment, somewhat larger. A very strong appeal has been made by Dr. Weinberg. However, the Commission has felt, even before this incident, that we should have a little further operating experience with the reactor experiment we have before we proceed with the larger one as recommended.

Chairman ANDERSON. Could you tell us what happened on that?

Mr. MCCONE. I would like Dr. Pittman to answer that.

Dr. PITTMAN. I may have to turn to people who have a little more information on it, but in essence I believe what happened was another case of instability of the fuel, in which the fuel deposited out similar to the way it did last year, causing an increase in the temperature, which caused a melt. And I think it is just another case of the fact that we have to learn a terrific amount about the stability of these uranium fuels before we can go ahead and plan to build larger reactors.

Chairman ANDERSON. But this has happened twice, now.

Dr. PITTMAN. It has happened twice. I would like to ask Mr. Stabler if I have properly stated that. Yes. I thought that was right, sir.

Mr. FLOBERG. When the second one happened, they were running the same kind of experiment as when the first one happened. So the conditions were similar. It really would verify the results of the initial situation.

Representative PRICE. May I ask Dr. Pittman a question?

Chairman ANDERSON. Yes. Dr. Pittman, Mr. Price wanted to ask a question.

Representative PRICE. The aqueous homogeneous reactor was one of the first ones in the family of reactors. We have been working on them many, many years. Can you tell me what the advantage will be if your research causes us to stick with this project?

Dr. PITTMAN. The major advantages of this, of course, are that you have the fuel in a system where it can be taken out of the reactor very

rapidly. You can reprocess it on a continuous basis. You can cut down on the total inventory of fuel that you have in your system and simplify handling and fabrication; of course, there is no fabrication of the solution. The problems are, though, that the whole system gets contaminated.

This is something I think we will want to investigate more carefully. But if we can overcome the difficulties as to the instability of the solution, it certainly offers potential for breeding and for simplicity of the system in the future.

Senator HICKENLOOPER. May I ask how long you think it will take to find this out? We have spent a lot of money on this system and have been working on it for a very long time.

Dr. PITTMAN. Well, sir, it is hard to predict when you can get an answer to a very difficult problem like this. It happens that this is one of the problems I believe I understand a little better than some of the physics problems that the other reactors have, since I am a chemist. My own personal opinion is that this is the type of a problem that does lend itself to solution, but it will take I would say a good many years of rather concentrated effort in the laboratory to develop enough information about the stability of these systems so that we can count on developing a reactor system that will be workable.

Senator HICKENLOOPER. Have you been able to get Oak Ridge to do anything about the slurry system that was proposed here a while back? Or will they just look at it and say it will not work?

Dr. PITTMAN. No, sir; I think Oak Ridge recognizes that in the long range a slurry system is a very important part of their program. I think they have recognized, however, that they have some serious problems.

Senator HICKENLOOPER. Well, are they doing anything about it, other than just putting it on the shelf?

Dr. PITTMAN. They are doing the slurry research in the laboratory. They are not trying to do anything in this reactor. It was to be a two-region reactor. But with the hole between the two, it is not possible to run slurries in one region. But they are doing work in the laboratory, sir.

Senator HICKENLOOPER. The only point: Are they so wedded to the system they started a long while ago that they will not go to another system or experiment with it?

Dr. PITTMAN. No, sir; I think Oak Ridge is willing to look quite seriously at the slurry systems. And the loop that was at the Pennsylvania Power & Light operation a couple of years ago is out at Oak Ridge, and I think they have done some loopwork on the slurry system itself.

Mr. MCCONE. Future plans on the aqueous homogeneous system will depend on what you mentioned.

I would like to delete paragraph 73.

Chairman ANDERSON. If you delete that, have there not been some news stories or comments that the Atomic Energy Commission in its 10-year program will emphasize certain types of reactors and deemphasize others? Do you feel that your 10-year program does that, picks out the pressurized water and the boiling water and emphasizes those and leaves off some of the other concepts?

Mr. McCone. No; I do not think so. I have run into those statements. I think what we have tried to do is to evaluate each one of these concepts and to see whether there were some that, if they met all of the prospects, the results would not be of material advantage to this country. Or if it goes on, we will drop them. We have the two water reactors, the pressurized and boiling water being the most advanced. And they seem to be most acceptable by the utilities who are used to handling water. It is the natural thing for them to do.

On the other hand, there are some limitations, in both temperature and pressure, and it is quite possible that sodium or gas will replace them ultimately.

Chairman Anderson. I was only trying to get some sort of a statement to the effect that the Atomic Energy Commission still intends to go forward in those things that seem to be promising as rapidly as you can.

Mr. McCone. Yes; I think that is true. We do intend to do that. But we do not intend to respond to every combination of coolant and moderator and reflector, just because it represents some ingenious idea. I think we have to recognize that any reactor concept has to go through three distinct stages of development. It has to go through the stage of the experimental reactor, or the reactor experiment, and sometimes a reactor experiment asks questions more than it answers them. And then you go into another experiment, and then you go into a prototype, and then you finally get to a full-sized plant. So you are into a program of maybe several hundreds of millions of dollars. Therefore I think we have to be quite selective. We have to be sure that if everything is successful, we have not merely repeated what we accomplished in other reactor concepts.

Chairman Anderson. I cannot quite find the words that I had in mind, but somewhere I saw a story that the Atomic Energy Commission fixed its course. It is going with this one and this one and this one. I rather had the impression that you were treating the whole field pretty carefully and pretty broadly, and I thought that a general statement on that might be of interest.

Mr. McCone. I think this is the most authoritative phase of our program.

(The following letter from Mr. McCone, dated March 10, 1960, referring to pars. 70–73, follows. The paragraphs referred to appear in the AEC's full statement on p. 133.)

U.S. Atomic Energy Commission,
Washington, D.C., March 10, 1960.

Hon. Clinton P. Anderson,
Chairman, Joint Committee on Atomic Energy,
Congress of the United States.

Dear Senator Anderson: Reference is made to my testimony before the Joint Committee on Atomic Energy on February 16, 1960. Paragraphs 70 through 73 of my prepared testimony covered the program for the aqueous homogeneous reactor concept. During my testimony several questions were raised relative to the significance of the recent second failure that had occurred in the HRE–2 core tank and the possible effect of this incident on long-range program plans. At the conclusion I stated that future plans for the aqueous homogeneous system would depend on a more complete analysis and evaluation of this failure, and requested that paragraph 73 be deleted from the prepared testimony. After further consideration of this matter, our long-range plans for the program are unchanged, and I wish to reinstate paragraph 73 into the record.

As was pointed in A. R. Luedecke's letter to you dated February 6, 1960, operation of the HRE–2 has been directed to obtaining further information on and, if possible, demonstrating at least a partial engineering solution to the fuel solution instability problem. During the run which was terminated on January 22, 1960, by the formation of the second hole, the reactor was being operated at various combinations of reduced system pressure and temperature. The purpose of the run was to determine the maximum stable power level at each of the selected conditions. In this type of operation, the reactor is deliberately pushed into unstable or borderline stability conditions to determine fuel stability limits with the present core configuration, and the risk of further core damage must be recognized as part of the price of these important investigations:

To investigate the possible mechanisms of fuel instability, a program of HRE–2 operations was formulated some time ago. This program consists of: (1) Changing fuel temperatures and pressures; (2) adding chemicals to the fuel; (3) improving hydrodynamics of core and blanket vessels.

To date only phases 1 and 2, above, have been investigated. These investigations have produced significant improvements in fuel stability. However, to achieve more satisfactory operating conditions, it is necessary to undertake phase 3 of the program, and current plans are to reverse the direction of flow through the core and to plug both holes in the core tank before resuming operation.

The formation of the second hole in the HRE–2 confirms and reemphasizes the severity of the fuel instability problem: it does not appear to indicate the presence of new or unforeseen difficulties. We therefore plan to continue research and development on a long-range basis, the magnitude, direction, and nature of the effort being guided by the outcome of the research and development work.

Sincerely yours,

JOHN A. MCCONE, *Chairman.*

NEW CONCEPTS PROGRAM

Mr. MCCONE. As technology is developing rapidly in many directions, the Commission must be alert to evaluate new reactor ideas as well as new ideas for major improvements in existing reactor types. However, a decision to proceed with the development of design alternates representing major technological advances depends upon an evaluation of the benefits expected to result. Early construction of inexpensive reactor experiments of the simplicity, size, and cost range of Borax and the organic moderated experiment may be required to help determine the technical feasibility of advanced designs which look promising.

The Los Alamos Molten Plutonium Reactor Experiment (LAMPRE) is under construction, and the High Temperature Gas-Cooled Reactor Experiment (Turret) is under design. Turret would establish the feasibility of operation with a gas coolant at temperatures above 2,000° F.

Typical of reactor types or reactor modifications that are currently being investigated are fused salt, pebble bed gas-cooled, and slurry or fluidized bed concepts. Other examples are listed in our written submission. In several cases, specific research and development is being carried out in areas critical to their evaluation.

FUTURE PLANS

Engineering studies, research and development, and evaluation of the new reactor concepts will be continued to the point where a decision can be reached either to build a reactor experiment or to terminate the work. During the next few years it is probable that three to five of these concepts will have reached a point where construction

of a reactor experiment will be justified. Subsequent evaluation of the results from these experiments may justify the construction of several prototypes.

(Statement of AEC's new policy on unsolicited proposals for advanced reactor concepts is contained in AEC letter dated March 17, 1960, and appears in "Hearing in AEC Authorizing Legislation, Fiscal Year 1960," p. 297.)

NUCLEAR TECHNOLOGY

Mr. McCone. In addition to the specific work carried on under individual power reactor projects, there is an area of more broadly based development in nuclear technology. The general objectives of this program are to provide basic data on reactor systems and related problems, to carry out engineering development of a general and fundamental nature, to investigate the feasibility and potential of new methods for improving reactors, and to provide tools, such as test and research reactors and remote handling devices, for use in reactor research and development.

Developments in this area should help to lower the cost of nuclear power generation through improvements affecting many types of reactors and through reductions in the overall cost of the reactor fuel cycle. I will summarize this highly technical but rewarding field. Our written submission will provide detail.

Briefly, our work in fuel and materials includes the fuel cycle development program inaugurated during 1958. We accepted 24 research and development proposals from 18 contracts with industrial organizations in this field during 1959, besides increasing our own effort through our laboratories and contractors.

In fuel reprocessing, we are broadening our attack on various types of fuels for many of which, at this time, proved technologies do not exist. We are exploring low decontamination, remote refabrication methods such as those being worked out in the pyrometallurgical plant associated with the second experimental breeding reactor. We hope to reduce costs throughout this field.

Chairman Anderson. Would you stop there?

Mr. Ramey had a question a moment ago.

Mr. Ramey. On your fuel cycle development program, is not accepting 24 proposals of relatively small amount with different outfits sort of spreading it pretty thin? Would it not be possible to obtain better results by larger contracts with fewer but diversified groups?

Mr. McCone. That was not our judgment, Mr. Ramey. We discussed the alternates and felt that this was about a proper balance of the size of contracts and the dispersal throughout the country.

Mr. Ramey. Is the Commission considering changing this at all? Awarding larger projects and fewer of them?

Mr. McCone. Well, we have not approached this question of fuel? element development from that standpoint. What we will do is to award contracts to fully utilize the capability of contractors or engineering firms who have developed an ability to render real assistance to us.

Problems in reactor safety will intensify as the number and variety of reactors increase. We are continuing experimental and analytical

work with transient test facilities, and in our laboratories. Chemical reactions, meltdown of cores, reactor kinetics are being studied, and we are seeking effective, economical methods of reactor containment.

In waste disposal, we are going ahead with field tests to supplement the work of laboratories, and making thorough examinations of systems for fixing and depositing large quantities of radioactive materials. This involves detailed study and analysis of many environmental factors.

These programs I have cited are in addition to studies on reactor physics, and developing and testing reactor components and associated equipment.

Together, these programs in nuclear technology help to fill the well from which we draw the essential information on which to base, and improve, our power reactors.

COSTS AND PLANS

The Commission has attempted to forecast the level of costs to support the plans we have presented for the civilian power reactor program. These forecasts are for planning purposes only. They cover research and development, including operating costs and waivers of fuel charges. They also cover design and construction of reactor experiments and prototype reactors, and general engineering support of the civilian power program. The forecast omits commercial plant costs. The years immediately ahead are more easily estimated than the years at the end of the period.

Our forecast of gross costs for the research and development and the experiments and prototypes I have named indicate average expenditures for 1961 to 1969 of about $200 million a year. For 1961, we estimate $250 million, exclusive of industry contributions. The bulk of these average expenditures from 1961 to 1969 for the civilian power reactor program probably will be made by the Government, but industry's share should be substantial. Industry also is expected to spend additional sums on its own plants—prototypes or commercial installations.

In the years covered by our forecast—1961 through 1969—we will be investing the estimated average of $200 million a year in the following things:

First, a broad program of general research and development feeding technology to all reactor programs, exploring new concepts useful for both small and large reactors, and providing support facilities such as test reactors.

Second, reactor experiments needed to prove or to develop reactor concepts for small or large power reactors. We can now foresee that some six of these will be needed. Others quite possibly will be proposed.

Third, prototypes will be needed to advance concepts which were proved out in reactor experiments. These will produce information and technology that can be extrapolated to commercial plants, small or large. Some 14 of these prototypes can now be foreseen.

Fourth, appropriate support of cooperative industry efforts as authorized by the Congress.

Out of the work represented by these forecast expenditures, and from the previous accomplishments of the Government and industry programs, we believe that, in the years ahead, the following can be accomplished:

First, large pressurized water and boiling water reactor powerplants initiated in 1960 probably would produce power at costs that are competitive with conventional powerplants over the life of the plant in certain high fuel cost areas where such large plants are practical.

Second, large organic-moderated reactors probably can reach a competitive stage of development by the middle 1960's on the same basis.

This is assuming that the research and development on fuel elements prove satisfactory.

Third, superheat in a large water reactor probably can be brought to a competitive cost level by the late 1960's.

Fourth, both light-water-cooled and organic-cooled reactors could develop a longer range potential of becoming economic in many areas.

Fifth, by the late 1960's fast breeder reactors may become competitive in many areas.

Sixth, somewhat later, probably in the early 1970's, large high-temperature, gas-cooled reactors probably could become competitive in high-cost areas.

Seventh, the economic potential of small power reactors will be developed both in projects directed to this end and as an outgrowth of technology developed for large reactors.

Eighth, other reactor concepts will be explored and, as warranted by technical development and economic potential, systematically advanced.

These are forecasts of probabilities as we view them on the basis of progress and analysis now in 1960. They are not certainties. We believe that they can be achieved by continued strong Commission leadership, by strong cooperation between Government and industry, by unceasing effort, and orderly, systematic promotion of worthwhile development and promising reactor concepts.

Chairman ANDERSON. Could I just ask you, there, Mr. Chairman, before you go on, about this cost element on breeders you have scheduled in the summary, where you set up $178 million for fiscal year 1960, research and development, and then $160 million on construction? Is that a little bit out of line? You will see from that we have spend $88 million up through 1959, and then you have $168 million in research and development and $160 million in construction.

Mr. MCCONE. What was the question? I had not seen this schedule.

Chairman ANDERSON. Dr. Pittman sent it to us today.

Mr. MCCONE. That is right.

Will you cover that?

Dr. PITTMAN. Senator, could I speak to this document? I did not hear what the question was.

Chairman ANDERSON. This indicates that you are going to spend a whole lot more money on the fast breeder than you are going to spend on natural uranium or various other things. This represents a judgment that the fast breeder is by long odds the most promising horse in the race.

Dr. PITTMAN. Sir, this document was sent to you as a result of a request from Mr. Ramey to give what would have been the expenditures had we carried out the entire program indicated in volume II. You know, in going through our studies, we have volume I, which was the current status; volume II, which was the long-range potential; and we went through a rather extensive program of research and development, which could be carried out for each of these. Mr. Ramey asked that we give the cost that would be incurred if all of those programs were carried out. That is what this document represents. It does not represent the cost that we are now proposing in the program as it actually has come out, because we are not proposing to carry out the entire program as it was represented in that volume II.

Mr. RAMEY. You are not proposing that on the fast breeder, either?

Dr. PITTMAN. No, sir; not quite. We are proposing here only one prototype, in connection with the fast breeder. In this one, there was the possibility of, I think, three prototypes. I do not have the figures right offhand; but that is the difference.

Mr. RAMEY. Will it be a proportional amount, between concepts?

Dr. PITTMAN. No; it will not be. What we have done is to take volume II, and we have gone through it, and tried to see what is reasonable in looking at all of these concepts, and brought you the program presented today, which is in essence the Commission program. So there is a difference between these costs and what we are actually proposing to do. These were furnished at your request.

Mr. RAMEY. Do you have the breakdowns on a comparable basis?

Dr. PITTMAN. You mean for the program we have talked about? I gave you yesterday, Mr. Ramey, informally, or left with you, another document, which gives something similar, showing that the fast breeder system has research and development at $140 million and a prototype construction estimated at $30 million. These are certainly rough estimates long into the future, but they do give you a total of $170 million for fast breeders.

Chairman ANDERSON. What I am trying to get at, Dr. Pittman: Can we put those figures into this record now, or should they be submitted back to the Commission and then submitted by the Commission to us?

Mr. Ink, did you want to get into this?

Mr. INK. I was just going to suggest, sir, that we submit figures for the record. This gives you an indication, but we would like to submit figures for the record.

Dr. PITTMAN. I think these were submitted more for staff review, and I think we had better submit a detailed breakdown for the record.

Chairman ANDERSON. Our problem is that we would like to ask questions on it. That is what we got these for, to ask questions. If it is still tentative, we will probably have to wait until you supply us with the figures, and then we will go back to questioning at a later date.

Representative HOSMER. In other words, Dr. Pitman, you say these are not subject to questioning at this time.

Dr. PITTMAN. The question was asked about volume II.

Representative HOSMER. But it has nothing to do with probing for a realistic answer or helpful answer. What you are going to do now is prepare some statistics on the basis of the program you have laid out here.

Dr. PITTMAN. We have said that this program as laid out here costs around $200 million a year. I have furnished informally to the staff the general breakdown of that, but I would rather furnish that in more detail.

Representative HOSMER. We can disregard these other figures, then?

Dr. PITTMAN. I think it has nothing to do with this program here.

Chairman ANDERSON. We do have a set of figures here furnished us.

(This set of figures and subsequent AEC corrections are on file with the Joint Committee.)

Mr. MCCONE. Where is that chart we had this morning? I can answer the question in this way, and go right down, item by item.

To accomplish what I have been reading about here for the last couple of hours, this will cost in general engineering support and experimental facilties $645 million, and it will anticipate expenditures for research and development on pressurized water of $70 million and of prototype construction on pressurized water of an equal amount, or a total expenditure on pressurized water of $140 million.

On boiling water, the figure will be $95 million. On nuclear superheat, the figure will be $80 million. And on organic cooled, the figure will be $100 million.

So those three concepts, together with the superheat, would involve research and development of $240 million. And prototype construction of $175 million; or a total of $415 million.

Now turning to your sodium-cooled fast reactor, there is indicated a research and development expenditure of $140 million, prototypes of $30 million, or a total of $170 million.

On the sodium-cooled thermal, $55 million. On the gas-cooled enriched——

Chairman ANDERSON. Which is divided, $25 million for research.

Mr. MCCONE. $25 million for research and $30 million prototypes. On the gas cooled, $100 million for research and development, and $30 million for prototypes, or a total of $130 million.

For heavy water, there is an expenditure of $55 million for research and development and nothing for prototypes. That is, in anticipation of the successful conclusion and approval of the Canadian arrangement.

On aqueous homogeneous, there is $65 million on research and development, $20 million for a prototype, and $15 million for an experimental reactor.

On new concepts, there is $45 million on research and development; $80 million on prototypes; and $15 million for reactor experiments. This makes a total of $460 million on research and development and $190 million for prototypes applied directly to sodium-cooled, gas-cooled, heavy water, aqueous homogeneous, and new reactor concepts. This totals $650 million for these concepts as compared to $415 million for the light water and organic concepts.

There would be $700 million for research and development on all concepts and $365 million for prototypes.

Now, not all of that money will be Government, because some of these prototypes may be built by industry, as indicated in the presentation. Some of this research and development will not go forward, because some of these programs will probably drop out. Others may [illegible] figures than indicated. This must be considered as a

best guess at this time. The grand total is $1,710,000,000, and no attempt has been made to divide it between private investment and appropriated Government money.

(For additional discussion on cost estimates of the AEC civilian power program, see "Hearings on AEC Authorizing Legislation, Fiscal Year 1961," pp. 270–280.)

Chairman ANDERSON. Now, Mr. Chairman, you have finished about 30 pages of your 60 pages. Would you like to take a seventh-inning stretch, or would you like to have someone else read on for you?

Mr. MCCONE. I will read to page 35, and that will conclude it, and then you can ask questions, if you would like.

Chairman ANDERSON. Go right ahead.

Mr. MCCONE. Concluding our presentation of the Commission's civilian power reactor program, I would like to summarize a few additional reactor programs, in some of which the committee has expressed special interest.

TEST REACTORS

Most fuel irradiation tests requiring thermal neutrons are now conducted in the Commission's materials testing and engineering test reactors. Some smaller Commission reactors also are being used for this purpose, and a few privately financed test reactors, such as those of Westinghouse and General Electric, have become available. Last year, the Commission sought to obtain a greater portion of the irradiation test needs from industry. As a result of an invitation the Babcock & Wilcox Co. proposal was selected as a basis for negotiation of a contract for use of space in a reactor to be constructed.

Due to the increasing needs, particularly in the Navy program, for thermal fluxes higher than available in existing or planned test reactors, the Commission, in August, contracted with Phillips Petroleum Co. for a conceptual design study for a high-flux test reactor incorporating the most advanced technology available. During the coming year the possible requirements for fast breeder fuel element test facilities will be studied.

Industry's and the Government's requirements for irradiation space in test reactors in the period 1960 through 1965 are being evaluated. The results will serve as a basis for determining the nature of arrangements for building a high-flux test reactor.

There seems to be no question but that we will need such a reactor. We will also need the services of the General Electric and Westinghouse reactors for some time to come, as well as the Babcock & Wilcox reactor, but the details of that study will be presented at a little later date.

PROCESS HEAT

One reactor development effort not directly associated with the generation of electricity is our program to develop nuclear reactors for industrial process heat. As indicated previously, the Commission has undertaken design and construction of a 40-mwe. pressurized water reactor to produce low-temperature process steam. The Department of the Interior will build an associated experimental plant in California which will use heat from this reactor to convert saline water to potable water.

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Work on high-temperature process heat is being carried on in a joint experimental program between the Commission and the Bureau of Mines at the latter's Appalachian Experiment Station, Morgantown, W. Va. The ultimate objective is use of heat from a nuclear reactor for gasification of coal. The previously described high-temperature, gas-cooled reactor experiment, designated "Turret," is a possible source of high-temperature industrial process heat.

THORIUM UTILIZATION

Four reactors discussed under specific concepts in part IV are scheduled to utilize thorium. These are the sodium reactor experiment, and the power reactors of Consolidated Edison, Rural Cooperative Power Association, and the Philadelphia Electric Co. Operating experience from these four plants and further development and testing at the homogeneous reactor experiment will provide a base for further evaluation. Should evaluation indicate a potential justifying further experimental or prototype reactors designed primarily for thorium utilization, necessary authorizations would be requested.

Specific problems of thorium utilization include fuel stability, corrosion, and the development of slurry or other systems suitable for fluid fuel thorium breeders.

CONTRIBUTIONS OF MILITARY REACTOR PROGRAMS

The military reactor programs have been of industrial importance from their inception. They have contributed, and on an increasing scale continue to contribute, technical information to the civilian reactor programs.

The naval reactors program has made many direct contributions. The pressurized water reactor, for instance, was selected for the Shippingport plant because full advantage could be taken of technology developed in the naval program.

All water-cooled reactors benefit from past development of the naval reactors program. Sodium technology and components were first developed for the submarine intermediate reactor.

The Army reactors program contributes to development of small powerplants for civilian purposes. Low-output plants provide a significant portion of the power generated today in this country. The Army objectives of ease of installation, operation, and maintenance, and minimum crew size and training requirements, are directly applicable to small civilian plants, particularly in remote locations. Among specific developments from the Army program are stainless steel—uranium oxide plate fuel elements and control rod drives, both subsequently used in the civilian program. The portable gas-cooled reactor ML–1 will be the first plant in operation which combines a reactor heat source with a closed gas-turbine cycle.

Representative PRICE. While you are on that paragraph about the Army reactors program, could you give us any information on your progress with the small-package reactors such as could be used for distribution in underdeveloped areas throughout the world?

Mr. MCCONE. For distribution where, sir?

Representative PRICE. For distribution throughout the underdeveloped nations.

Mr. MCCONE. Here the problem is economics, Mr. Price. The best approach that we have been able to make is the small pressurized water reactor, which we have under construction, to demonstrate the economics of a reactor generating from 15 to 20 megawatts electrical. When these reactors get very small, they get very expensive.

Representative PRICE. Have we made any great progress in this area of the small-package reactor?

Mr. MCCONE. No; not in that power range.

Representative PRICE. We have not developed any real portable reactor?

Mr. MCCONE. The AEC has several types under design and development, but does not yet have them in being. The Army is procuring a portable version of the Fort Belvoir plant for delivery this spring.

Representative PRICE. Whatever happened to the suggestion that we place part of the reactors for the Navy and a token for the Army? Do those proposals still lie?

Mr. MCCONE. We were very hopeful we could make a joint undertaking with the Navy for about a 20-megawatt reactor at Guam. However, the Navy decided to proceed or to request authority for a conventional plant to meet their increasing power demands.

Representative PRICE. But they at least gave some tentative assurance to the congressional committee that while they were proceeding with part of an immediate program on the conventional plan, they would give consideration at the next implementation to a nuclear powerplant. Is such a proposal still in the mill?

Mr. MCCONE. No. The Guam plant is not in the mill at the present time. We had hoped it would be, and we might be able to revive it. But right now we do not have it. We have a complete study and a report being prepared on all of the small reactors in the 5- to 40-mwe. range to meet the anticipated power requirements for various remote installations of the military services. This report has been requested by your committee and I think is to be submitted in a relatively short time.

(The material referred to follows:)

U. S. ATOMIC ENERGY COMMISSION,
Washington, D.C., March 31, 1960.

Hon. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Congress of the United States.

DEAR SENATOR ANDERSON: In section 113 of Public Law 86-50 the Commission was directed to undertake design and engineering studies of a reactor for remote military installations. As outlined in our letter of September 1, 1959, our approach was as follows: (1) the Department of Defense (DOD) provided forseeable 5–40 electrical megawatt power requirements at remote installations in the period 1963–70; (2) a contractor developed designs and cost estimates for nuclear and conventional plants for 10 applications for which nuclear power would compete most favorably with conventional power; (3) the DOD indicated which applications would be of most interest to the DOD considering costs and all other factors deemed appropriate.

From among eight firms proposing to perform the study, Kaiser Engineers was selected, and a contract was executed as of August 17, 1959.

The choices of reactor types for the various applications should not be construed as a preference by the Commission for one particular concept over another. The choice was limited to pressurized and boiling water reactors based on the

existing state of the art, and the final choice for each site was based primarily on the availability of existing designs for two reasons: (1) more reliable cost estimates available from vendors, and (2) more economical to adopt or modify slightly an existing design than to design a new reactor. If a decision were made to proceed with any of these particular projects, the ultimate designs might or might not be the same as reflected in this study.

The DOD can be expected to appraise the economics of nuclear power in terms of costs for which the DOD must budget; therefore, the study was prepared in these terms. Specifically, the cost estimates do not reflect interest on the investment and fuel-use charges; therefore, they do not represent total costs to the Government. Furthermore, because they do not include cost of land, taxes, indemnity insurance, and return on investment, the figures should not be compared to commercial costs.

Enclosure 1 hereto summarizes Kaiser's cost estimates and reflects revisions to those estimates based on our evaluation of the Kaiser figures. The estimated total project costs include, in each case, Government costs to cover such items as contract administration, resident engineering services, and Government travel. In a Commission construction project, such Government costs would have to be provided for in the operating budget. Enclosure 2 reflects our technical evaluation of the study and provides details of our evaluation of Kaiser's cost estimates.

In our evaluation of the study, we found only one cost estimate with which we differ to an extent that has an important impact on the overall result: the vendor's estimates for the plant at McMurdo Sound omitted several significant items. These have been called to the vendor's attention and he has confirmed the accuracy of the adjustments made by our evaluation. For our revised estimates we have used the higher, more conservative figures, and the effect is reflected in enclosure 1. It should nevertheless be emphasized that the Commission does not regard the estimates in this report as guaranteed prices inasmuch as they are based primarily on vendor estimates rather than bids.

Our technical evaluation of the study has disclosed but one major deficiency: the nuclear and standby systems designed for Thule AFB will not meet the requirements of the Air Force for that installation. Specifically, the use to which the power will be put makes it mandatory that power be available on a continuous basis; however, inherent in Kaiser's recommended system there is a potential outage of 2 minutes which is the time required for the standby system to pick up the load and which would occur any time the nuclear plant shut down without at least 2 minutes of advance warning. The technical changes necessary to overcome this deficiency and the cost of such changes are being investigated further.

There is one fact concerning the plants for the Nike-Zeus application which should be noted. The system reported is adequate to meet the power requirement as stated to the contractor; however, subsequent changes in the Nike-Zeus concept indicate that greater power of a higher quality may be required. Therefore, because the ultimate power requirements for Nike-Zeus installations are still uncertain, the cost estimates for nuclear power at Nike-Zeus installations must necessarily be uncertain also.

Because of time limitations, the DOD was requested to determine its relative interest in the 10 applications on the basis of the unevaluated study results. Although the estimates have changed somewhat as a result of our subsequent evaluation, we are confident that such changes would have had no effect on the position reported by the DOD.

The DOD has indicated the following order of interest in the applications investigated: (1) McMurdo Sound; (2) Thule AFB; (3) Guam; and (4) Inchon.

You will be interested to learn that we have extended our contract with Kaiser in order that the contractor may keep the study up to date and also investigate additional possible applications of nuclear power at remote military installations, including those falling below the 5–40 electrical megawatt range of the original study. On February 16, 1960, in view of sharpening interest in Antarctic applications, we directed that Kaiser study the Pole and Byrd Stations in essentially the same fashion as the 10 applications in the original study. The expected completion date for these additional reports is May 1, 1960.

By separate transmittal, we are forwarding copies of the complete report prepared by the contractor. We will be pleased to provide any additional information which you may require.

Sincerely yours,

JOHN A. MCCONE, *Chairman.*

Cost analysis and summary data, remote military power applications study

	Okinawa	Guam	Thule AFB	NORAD	Asmara
I. Summary data, nuclear:					
(*a*) Power requirement	40 mwe	20 mwe	25 mwe plus heat	7 mwe	5 mwe.
(*b*) Total yearly power	290 $X10^6$ kw.-hrs.	145 $X10^6$ kw.-hrs.	170 $X10^6$ kw.-hrs.	52.6 $X10^6$ kw.-hrs.	43.8 $X10^6$ kw.-hrs.
(*c*) Plant operating factor	80 percent	80 percent	80 percent	100 percent of average.	100 percent of firm.
(*d*) Reactor size	150 mw	75 mw	130 mw	28 mw	28 mw.
(*e*) Reactor type	BWR	BWR	BWR	PWR (SM-2)	PWR (SM-2).
(*f*) Fuel enrichment	1.9 percent	3.4 percent	2.2 percent	90+ percent	90+ percent.
(*g*) Number of reactors	1	1	1	2	1.
(*h*) Rated capacity of plant	41.4 mwe	20.7 mwe	25.4 mwe	10.8 mwe	5.4 mwe.
(*i*) Net firm power	20.7 mwe	0	15 mwe	6 mwe average	5 mwe.
(*j*) Type of installation	Land	Platform barge	C-3 hull	Underground	Land.
(*k*) Location	Kin	Tumon Bay	Barge basin	Camp Carson	Tract E.
(*l*) Nuclear pay-out time for DOD	12.1 years	19.1 years	5.1 years		
(*m*) Nuclear savings (or excess cost) over 20-year plant life	$8,488,000	$430,000	$31,838,000	($12,076,000)	($7,435,000).
II. Summary data, conventional:					
(*a*) Rated capacity of plant	41.4 mwe	20.7 mwe	25.4 mwe	9 mwe	7.5 mwe.
(*b*) Net firm power	20.7 mwe	0	15 mwe	4 mwe (6 mwe average).	5 mwe.
(*c*) Type of system	Steam turbine	Steam turbine	Steam turbine	Diesel engine	Diesel engine.
(*d*) Fuel cost per gallon	$0.104	$0.108	$0.144	$0.156	$0.130.
III. Nuclear plants:					
(*a*) Kaiser estimates:					
1. Total project cost [1] (including Government costs)	$24,020,000	$17,380,000	$22,860,000	$11,900,000	$6,110,000.
2. Annual DOD budgeted costs	$1,566,000	$1,092,000	$1,702,000	$910,000	$725,000.
3. Cost of power [2]	9.5 mills	13.5 mills	16 mills	28.6 mills	23.5 mills.
(*b*) Revised estimates:					
1. Total project cost [1] (including Government costs)	$23,702,000	$17,305,000	$22,622,000	$11,746,000	$6,121,000.
2. Annual DOD budgeted costs	$1,566,000	$1,092,000	$1,702,000	$1,081,000	$881,000.
3. Cost of power [2]	9.5 mills	13.5 mills	15.9 mills	31.7 mills	27.1 mills.
(*c*) Design engineering costs	$1,700,000	$900,000	$1,200,000	$700,000	$250,000.
IV. Conventional plants:					
(*a*) Kaiser estimates:					
1. Total project cost [3] (including Government costs)	$10,770,000	$8,235,000	$11,720,000	$5,070,000	$3,075,000.
2. Annual DOD budgeted costs	$2,637,000	$1,567,000	$3,839,000	$811,000	$675,000.
3. Cost of power [2]	10.9 mills	13.6 mills	24.8 mills	20.2 mills	18.9 mills.
(*b*) Revised estimates:					
1. Total project cost [3] (including Government costs)	$10,770,000	$8,235,000	$11,720,000	$5,070,000	$3,086,000.
2. Annual DOD budgeted costs	$2,637,000	$1,567,000	$3,839,000	$811,000	$661,000.
3. Cost of power [2]	10.9 mills	13.6 mills	24.8 mills	20.2 mills	18.6 mills.

See footnotes at end of table, p. 46.

Cost analysis and summary data, remote military power applications study—Continued

	Super Sage	Nike-Zeus	Inchon	Atlantic Barge	McMurdo Sound
I. Summary data, nuclear:					
(a) Power requirement	5 mwe	10 mwe	10 mwe	20 mwe	5 mwe.
(b) Total yearly power	28×10^6 kw.-hrs	87.6×10^6 kw.-hrs	70×10^6 kw.-hrs	149×10^6 kw.-hrs	26.3×10^6 kw.-hrs.
(c) Plant operating factor	100 percent of firm	100 percent of firm	80 percent	85 percent	100 percent of firm.
(d) Reactor size	28 mw	28 mw	40 mw	83 mw	11.4 mw.
(e) Reactor type	PWR (SM–2)	PWR (SM–2)	PWR	PWR	PWR (PM–1), (uncontained).
(f) Fuel enrichment	90+ percent	90+ percent	4 percent	3.63 and 4.55 percent.	90× percent.
(g) Number of reactors	1	2	1	1	3.
(h) Rated capacity of plant	5.4 mwe	10.8 mwe	10 mwe	20 mwe	4.6 mwe.
(i) Net firm power	3.2 mwe	10 mwe		10 mwe	3 mwe.
(j) Type of installation	Underground	Land	EC2–S–C1 Hull	C–3 Hull	Land.
(k) Location	(Classified)	(Classified)	Inchon Harbor	Atlantic area	NAF.
(l) Nuclear pay-out time for DOD		(219 years)		(32 years)	4.9 years.
(m) Nuclear savings (or excess cost) over 20-year plant life	($7,407,000)	($5,766,000)	($7,325,000)	($5,104,000)	$21,580,000.
II. Summary data, conventional:					
(a) Rated capacity of plant	4.8 mwe	15 mwe	12.5 mwe	20 mwe	4.8 mwe.
(b) Net fire power	3.2 mwe	10 mwe	7.5 mwe	10 mwe	3 mwe.
(c) Type of system	Diesel engine	Diesel engine	Diesel engine	Steam turbine	Diesel engine.
(d) Fuel cost per gallon	$0.156	$0.209	$0.104	$0.096	$1.06.
III. Nuclear plants:					
(a) Kaiser estimates:					
1. Total project cost [1] (including Government costs)	$9,270,000	$11,800,000	$11,700,000	$20,970,000	$9,680,000.
2. Annual DOD budgeted costs	$521,000	$1,285,000	$808,000	$1,114,000	$772,000.
3. Cost of power [2]	35.2 mills	21.4 mills	19.9 mills	14.5 mills	47.7 mills.
(b) Revised estimates:					
1. Total project cost [1] (including Government costs)	$9,106,000	$11,836,000	$11,565,000	$20,994,000	$11,340,000.
2. Annual DOD budgeted costs	$629,300	$1,550,000	$778,000	$1,225,000	$917,000.
3. Cost of power [2]	38.7 mills	24.4 mills	19.4 mills	15.3 mills	56.4 mills.
(c) Design engineering costs	$530,000	$400,000	$600,000	$360,000	$470,000.
IV. Conventional plants:					
(a) Kaiser estimates:					
1. Total project cost [3] (including Government costs)	$4,120,000	$5,490,000	$4,960,000	$7,390,000	$4,420,000.
2. Annual DOD budgeted costs	$471,000	$1,579,000	$756,000	$1,621,000	$2,342,000.
3. Cost of power [2]	24 mills	21.2 mills	14.4 mills	13.4 mills	97.5 mills.
(b) Revised estimates:					
1. Total project cost [3] (including Government costs)	$4,865,000	$5,490,000	$4,960,000	$7,390,000	$4,420,000.
2. Annual DOD budgeted costs	$471,000	$1,579,000	$742,000	$1,650,000	$2,342,000.
3. Cost of power [2]	25.5 mills	21.2 mills	14.1 mills	13.5 mills	97.5 mills.

[1] Includes contingency at 12 percent and Government costs at 6 percent.
[2] Includes 5 percent depreciation per year plus annual DOD budgeted cost.
[3] Includes contingency at 8 percent and Government costs at 6 percent.

NOTE.—The costs and unit costs per kilowatt-hour do not reflect interest on investment and fuel use charges, and therefore do not represent total costs to the Government. Furthermore, because they do not include cost of land, taxes, indemnity insurance, and return on investment, these figures should not be compared to commercial costs

Chairman ANDERSON. Mr. Ramey?

Mr. RAMEY. Has there not been a proposal that the Navy pay the conventional cost of a nuclear powerplant for Guam, and that the Commission pay the incremental cost, and was this not looked on rather favorably?

Mr. MCCONE. Yes; there were some discussions, but it was decided not to proceed that way.

Representative PRICE. That was the suggestion to which I had reference.

Mr. MCCONE. That is right. It was decided not to proceed with that.

Mr. RAMEY. Perhaps it was thought that this reactor might be almost economical at Guam in relation to the fuel prices, and therefore maybe the Navy ought to pay for it entirely; but that would raise their capital contributions, and at this point perhaps the Navy lost interest.

Mr. MCCONE. We put up a very persuasive argument. I thought we were going to win it for a while, Mr. Ramey, but we did not.

Chairman ANDERSON. Well, if you need some recruits, there are several up here who will be glad to try to help you in that battle.

Mr. MCCONE. The aircraft reactors program, which includes the direct-cycle, indirect-cycle, Rover, Pluto, and Snap projects, has provided much new and extremely useful information to civilian reactor technology. These projects have been the major source of data on very high temperature effects on reactor materials, and components. This program also produces very useful data in the lower temperature ranges on shielding and on the effects of radiation on organic materials.

Radioisotope power technology developed under the Snap program is readily usable for special power applications, such as remote unattended weather stations. Technology in power conversion has also been advanced by research in thermoelectric and small power conversion equipment. Progress is being made by the Rover advanced concept group at Los Alamos in their research on a very promising energy conversion device—the plasma thermocouple.

During the past year, a revised classification guide permitted release of additional information about military reactors. As a result, only that information which reveals features essential to the design, construction, or operation of specific military reactors remains classified. The aircraft reactor experiment at Oak Ridge National Laboratory was completely declassified, as was the aircraft reactor test there, and the supercritical water reactor.

Information declassified and available from these reactor programs includes fused salt fuels and liquid metals technology, such as the compatability with stainless steel of sodium, sodium-potassium, bismuth and lead. In addition, technology associated with the nichrome V fuel element desgned for the direct-cycle reactor has been declassified and information on the behavior of this material in a reactor environment will soon be made available.

Chairman ANDERSON. You mentioned in paragraph 103:

As a result, only that information which reveals features essential to the design, construction, or operation of specific military reactors remains classified.

1 Includes contingency at 4 percent per year plus annual DOD subsidy.
2 Includes 5 percent depreciation and Government costs at 6 percent.
3 Includes contingency at 8 percent and Government costs at 6 percent.
Furthermore, investment, these figures should not be used return on investment,

I do not regard the Rover as a specific military project, and I was happy that the Atomic Energy Commission gave us some help in clearing details of schedules and appropriations, and things of that nature, and we hope that you will continue to try to make as much of that project available as prudence would dictate. I realize there are some possibilities that may have military significance later on.

Mr. McCone. Yes; we are glad to make as much information available as we can. There is some possibility that Rover may have a military application and, for that reason, certain phases of it should be classified.

Chairman Anderson. I just wanted to express our appreciation for getting as much out of it as we did.

Mr. McCone. These declassified research and development documents are made available to the public through our standard distribution channels and contribute materially to industrial knowledge.

MARITIME PROGRAM

The effect of the maritime reactors program thus far has been chiefly upon the industrial and official bodies associated with the development, design, construction, and forthcoming test operation of the NS *Savannah*—the world's first nuclear-powered merchant ship. These groups range from the reactor designer, naval architect, and shipbuilder to the regulatory bodies and local port authorities in the United States and abroad.

From the inception of the *Savannah* project, normal commercial practice has been followed in order to establish procedures for possible future nuclear vessels. The crew has been selected from the officers and men of the American merchant marine. The ship is being constructed in accordance with established codes and regulations of both marine and nuclear industries.

I would like to stop at this point, if agreeable to you; and we could continue at your convenience with the evaluation of the foreign nuclear power program, to be presented by Commissioner Floberg.

(Short recess.)

Chairman Anderson. We will resume.

I think we will just say it is pretty late, and the members of the committee have asked me not to go on.

I think, if you do not mind, Mr. Floberg, we will go on with you tomorrow, because this has been a rather long-winded session. I think we will break now and start tomorrow at 2 p.m..

(Whereupon, at 4:25 p.m., Tuesday, February 16, 1960, the hearing was adjourned, to reconvene at 2 p.m., Wednesday, February 17, 1960.)

DEVELOPMENT, GROWTH, AND STATE OF THE ATOMIC ENERGY INDUSTRY

WEDNESDAY, FEBRUARY 17, 1960

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
Washington, D.C.

The committee met, pursuant to recess, at 2 p.m., in room P–63, the Capitol, Senator Clinton P. Anderson (chairman of the Joint Committee) presiding.

Present: Senators Anderson and Aiken; Representatives Durham, Holifield, Price, Aspinall, Hosmer, and Westland.

Also present: James T. Ramey, executive director; John T. Conway, assistant director; George F. Murphy, Jr., professional staff member; and Richard T. Lunger, technical adviser.

Chairman ANDERSON. The committee will be in order.

We will resume the Commission's testimony on the development, growth, and state of the atomic energy industry today with Mr. Floberg as our first witness. I understand that he will lead off with page 36 of the Commission's statement on the evaluation of foreign nuclear power programs.

After we finish this discussion, it is understood that Mr. Floberg will resume the discussion of industrial activities, page 42, to be followed by Admiral Rickover, whom we are very happy to welcome here, on the industrial aspects of the naval program. Then we will take up isotope development and regulatory activities which I understand Mr. Graham will take over.

May I interpolate there, Admiral Rickover, when you are up here for your discussion, I understand that you very recently returned from a trip to Britain. If you have any comments you want to make, this group is receptive to your comments and we will be glad to have anything you can give us on the British program.

Yesterday we were on the projected cost of the Commission's 10-year program as related to its projected cost for the optimum development of concepts. I believe it would be desirable if the staff of the Commission would get together with the committee staff and work up some cost objectives for inclusion in the record for possible discussion at a later date.

(See also letter dated March 7, 1960, on p. 149. For additional data on AEC civilian reactor development cost estimates, see "Hearings on AEC Authorizing Legislation, Fiscal Year 1961," pp. 271 and 272.)

Chairman ANDERSON. In the event we do not finish our discussion today, we will consider carrying on tomorrow morning and possibly next week.

Mr. Floberg, we are very happy to have you with us and happy to have you proceed. We are happy to see the vice chairman of the committee, Mr. Durham, here with us also.

STATEMENT OF JOHN A. McCONE, CHAIRMAN, AND JOHN F. FLOBERG, COMMISSIONER, ATOMIC ENERGY COMMISSION

Mr. FLOBERG. Thank you, Mr. Chairman.

Before we leave the subject of the reactors, I am going to present on behalf of the Commission a brief evaluation of the foreign nuclear power program.

The joint power reactor program between the United States and the European Atomic Energy Community has not developed to the extent originally expected. Factors with which you are acquainted have sharply reduced the original urgency for immediate construction of large-scale nuclear power plants for some 1 million kilowatts total capacity.

Long-term interest in nuclear power is continuing, but the emphasis is shifting in Western Europe, as elsewhere, to technological developments leading toward the reduction of costs rather than to early large-scale construction.

Only one definitive proposal—that of the Italian utility, Senn—was received in the joint U.S.-Euratom nuclear power reactor program by the deadline of last October. Our staff in Brussels is assisting the Euratom staff in working with the representatives of the Franco-Belgian group, which has reaffirmed its intention and ability to submit a definitive proposal.

Completion of the project would run over the December 31, 1963, deadline, but still could be undertaken in the second phase of the program which calls for completion by December 31, 1965.

The German utility study club group, AKS (Arbeitsgemeinschaft Kernkraftwerkes Stuttgart), has advised it can no longer hold out the promise of a binding commitment for the construction of a nuclear power plant under the joint program. Therefore, this project will not be included in the 1963 phase of the program and may be out permanently.

The Commission has carefully considered the Euratom program in light of the present circumstances. The U.S. policy on the importance of Euroepan economic and political integration has not changed. Euratom fosters such integration.

While the need for nuclear power as an immediate additional power source in Europe has lessened, the construction and operation of American-designed nuclear plants in Western Europe by the end of 1965 would still be of some technological benefit to the United States. These benefits would include the opportunity for additional demonstration of reactor concepts developed in the United States.

In the interim, engineering and fabrication of such plants, and the creation of new facilities where improvements may be tried and demonstrated, will be useful to our technology. The operation of such plants will provide statistical information on fuels and reactor performance which would be of value.

We have approved the Senn proposal recommended to us by the U.S.-Euratom Joint Reactor Board as a generally satisfactory project

and as an acceptable basis for development of such necessary subordinate arrangements as the Euratom-Senn contract, the fuel-cycle guarantee contract, and the U.S. fuel supply, plutonium purchase and reprocessing contracts. When these arrangements become definitive, we shall request congressional authorization of the appropriate fuel-cycle guarantee.

With respect to the two reactors currently authorized for 1965, we continue to believe that an invitation should be issued at an appropriate time.

Chairman ANDERSON. I do not quite understand that. What do you mean by that?

Mr. FLOBERG. By that we mean, Senator, that under the Euratom Cooperation Act, as you will recall, there is a provision that says two reactors may be completed as late as December 31, 1965.

Chairman ANDERSON. The Joint Committee put that in there. There was nothing in the original proposal. It was all 1963. The Joint Committee felt you might not get it until 1965, so we revised that somewhat.

One of these might be the Belgian, and there is another one you feel should be held over for a while?

Mr. FLOBERG. The two seats at the table are still vacant, Senator, and nobody has asked to occupy either of them. Our thought is, however, that this Franco-Belgian project may mature here in the next few months and may ask for admission to the program, and there may be one other coming in that could be completed by December 31, 1965, possibly the AKS one to which I referred previously, possibly some other one that has been talked about that is in a more initial stage.

Chairman ANDERSON. The Germans say the AKS is out.

Mr. FLOBERG. Out for 1963 and may be out permanently.

Chairman ANDERSON. Is there a possibility for the Belgian for 1965? It is out for 1963.

Mr. FLOBERG. They could not possibly complete it by 1963.

Chairman ANDERSON. Isn't it out?

Mr. FLOBERG. Out of 1963; yes, sir.

Chairman ANDERSON. It is still in for 1965 and there may be one other at a later date. So for the 1963 class we will just have the Senn reactor?

Mr. FLOBERG. That is affirmative.

Representative HOLIFIELD. The Senn reactor was started before Euratom. This was a project that was not started under Euratom, but started before Euratom; is that not true?

Mr. FLOBERG. The project was at an advanced stage before the Euratom Cooperation Act was even passed. We discussed it during the initial hearings.

Representative HOLIFIELD. So actually there has been no project started under the Euratom program.

Mr. FLOBERG. The Euratom program has produced no new reactor project that is in any definitive stage.

Representative HOLIFIELD. Will the Euratom terms give to the Senn project any advantage over what it would have had if we had not passed Euratom legislation?

Mr. FLOBERG. Yes; there will be some, such as the fuel element guarantee backup, the deferred payments on the fuel, although it is arguable as to whether it would have been part of the other deferred payment plan that we now have for non-Euratom projects.

At least it is the beneficiary of the deferred payment arrangement. And the plutonium buy-back contract. Then it also affords the protection of the clause in the agreement for cooperation with regard to reprocessing availability. These are all advantages that it would not have had if we had not had the Euratom program or if we had not had some other program take its place.

Representative HOLIFIELD. You feel that the Euratom program will bail the Senn project and insure its completion?

Mr. FLOBERG. I do not think it is going to bail it out, Mr. Holifield. We never had any intention that it should. I think the project would have gone ahead whether or not we had the Euratom arrangement. I do not think that Euratom can be given much credit for having kept the Senn project going.

Representative HOLIFIELD. There will be considerable financial benefit to it from the advantages they get under Euratom.

Mr. FLOBERG. It will be some advantage, but I do not think it is enough to make the difference between the project proceeding or not proceeding. It was enough advantage, Mr. Holifield, that they were anxious to come under the Euratom tent. So they thought it was an advantage. There is no question about that.

Chairman ANDERSON. The letter that went to Ambassador Butterworth—you are undoubtedly more familiar with this than I am—in section 6(b) he says:

> The closing of the 1963 invitation and the entrance of the 1956 invitation would certainly not serve as an incentive for speeding up projects now well under way. We therefore think it advisable to revert to our proposal for merging the two phases into one single 1965 program.

What did they mean by that proposal?

Mr. FLOBERG. This letter just came in a few days ago, Senator, and it was forwarded to the Joint Committee promptly.

Chairman ANDERSON. I am not questioning that. They say we think it is advisable to revert to our proposal. They must have made a previous proposal.

Mr. FLOBERG. I misunderstood your question. This was first suggested in a letter from Mr. Hirsch of a few weeks ago—I do not recall exactly—and I do not recall the wording of his letter at that time, but I do recall that he did say that what he thought should be done was that December 31, 1963, should be erased, so to speak, and the program should be regarded as having one date, namely, December 31, 1965.

Under the present terms of the law, we cannot do that. Under the agreement for cooperation we cannot do it either. I thought that was clear to all concerned, but perhaps it was not.

I might go on to say that this suggestion does not appeal to me particularly. I think that we ought to keep the temporal punctuation marks that we had all along. I see some advantage to doing what is suggested here, but on the other hand, I think that we ought to continue to regard the 1965 phase of the program as a two-reactor phase at this moment.

If some reason comes up why we should change our approach, we ought to consider changing it. At the moment I see no good reason for doing that.

Representative HOLIFIELD. The only reason the committee put these extra years into the bill was because we had no confidence that the original proposal would take place by 1963. We felt that by extending it 2 more years for two more reactors it might give a chance for a little bit longer stretchout. We were not quite as optimistic as the proposers of Euratom.

Mr. FLOBERG. The idea, as you recall also, is that it would give new reactor concepts a chance to compete and they would not have been in a position to compete on a December 31, 1963, completion date. We were speaking in terms of gas cooled in those days, if you will recall.

It might have been possible for them to have developed the technology a little more in the extra 2 years so they could have competed with what we then called proven-type reactors. I do not think there is any doubt they could have completed these projects by December 31, 1963, if they buckled down to it.

I never thought that date was unrealistic, although there was difference of opinion on it. If the utilities and authorities in question had wanted to complete these projects by December 31, 1963, they could have done so. There is not the slightest doubt in my mind about that.

Shall I proceed, Mr. Chairman?

Chairman ANDERSON. Yes; go right ahead.

Mr. FLOBERG. The joint research and development program supported by the United States and Euratom gained widespread attention in this country and in the European community. To date, proposals with a dollar value of almost $3.34 million have been approved by the Joint Research and Development Board.

Of this, $1.7 million worth will be performed in the United States at our expense. A total of $600,000 has already been contracted for and the remainder is in negotiation. Similarly, Euratom has contracted for about $449,000 of the $1.65 million to be done in Europe, with the remainder in negotiation. All of the proposals approved so far, both for U.S. and Euratom financing, cover research and development related to water reactors, chiefly in the field of fuel-cycle studies.

We propose to continue the research and development program but limit it to a modest amount in connection with boiling water reactors, including work having particular reference to the Senn project. This limitation would apply until responsive proposals to build reactors have been received in connection with invitations for 1965.

Apart from continuing the joint reactor program and its associated joint research and development program within their present framework, we will, of course, keep in close consultation with Euratom for the purpose of identifying any additional cooperation which would be of mutual technical benefit.

Chairman ANDERSON. I indicated the other day I would like an answer to the question of what effect the failure of the Euratom program will have on the domestic atomic equipment industry. Should consideration be give to allocating for the domestic program some of the funds which would have gone into the international program?

Mr. FLOBERG. We talked about that specific question, Senator, to try to line up the effects of the substantial failure of the individual reactor projects to meet the October deadline. Some of the effects are, of course, that American industry has spent a considerable amount of money preparing these proposals and has done considerable work on design and other preliminary work necessary to the submission of those proposals. That is a disappointment to all concerned.

Another effect is that the experience that we anticipated would be gained in design, engineering, fabrication, construction, and production of data from operation will now obviously not be availabe.

This was always considered to be cumulative rather than standing on its own feet, but nevertheless it is an impact. As far as diverting the funds or financial benefits that would have been available to the Euratom projects, it is pretty hard to relate the domestic program to the Euratom program in that sense.

For example, one of the benefits of the Euratom program was the availability of funds from the Export-Import Bank. It seems obviously inappropriate to start putting Export-Import Bank funds into the capital costs of domestic reactor projects.

Chairman ANDERSON. I realize that, but money of the Export-Import Bank still comes out of the Treasury.

Mr. FLOBERG. It is Uncle Sam's money; yes, sir.

Chairman ANDERSON. Take for example the first one, the Senn reactor. The Senn reactor is being financed by the World Bank and not the Export-Import Bank and, therefore, no part of the $135 million has been committed as yet.

Mr. FLOBERG. That is correct.

Chairman ANDERSON. Probably that is advantageous because the "buy American" provision was dropped out of the arrangement with Euratom after we had some pretty strong assurances in this room that it would be in there. But nonetheless there is no commitment on the $135 million.

Unless and until some proposal comes up that requires that, that frees some money there. We had some money in for fuel guarantees. Do you think any of that money is going to be needed?

Mr. FLOBERG. No; I do not think it is.

Chairman ANDERSON. How much was that?

Mr. FLOBERG. Yes; but you remember when we testified here we expressed the hope that none of it would be required.

Chairman ANDERSON. I know you expressed the hope. I had some of it cut out.

Mr. FLOBERG. That has been pretty well superseded by industrial manufacturers' guarantees on fuel performance.

Chairman ANDERSON. Sure. That saves money for the Treasury of the United States.

Mr. FLOBERG. We are all glad to hear of that.

Chairman ANDERSON. $50 million for research, $10 million a year for 5 years. How long have we been at this and how much have we spent?

Mr. FLOBERG. We have been going through a year and a half.

Chairman ANDERSON. We have spent some $500,000.

Mr. FLOBERG. We have not spent that much, Senator. We have contracted for some $600,000.

Chairman ANDERSON. So actually a good part of the $50 million is going to be available. This is supposed to be for research on new types of reactors that were going to be built; and if the reactors are not going to be built, obviously that money can be saved.

I am only trying to say that the Commission came in here yesterday with a program for some reactors that might look to some people as if they will run into money.

Mr. FLOBERG. This last item that you referred to——

Chairman ANDERSON. But these other things will relieve some of the obligations and not make it look so big, and probably it would be desirable to have some domestic development going on if the European development is not going on.

Mr. FLOBERG. Certainly the last item to which you refer is the one that suggests itself as a place where more work can be done in the United States without regard to the joint program. There is no doubt about that.

The other things, it seems to me, Senator, are not particularly translatable into the U.S. program. But I do not see any reason why they should not be considered for possible availability. It seems to me that they were cut to fit the program that we had in mind and they do not quite fit the domestic program.

If it is just a matter of dollars, I am sure the Commission is going to consider its program as an entity and a unity, and it will be prepared to request whatever dollars it thinks necessary to support a vigorous and aggressive program.

Chairman ANDERSON. When the so-called "Three Wise Men" came over here, they talked about 15 million kilowatts. Now it is down to 150,000.

Mr. FLOBERG. Those are different dates. They were talking about 15 million kilowatts at some other date. I do not remember. I think it was 1970.

Mr. RAMEY. 1967.

Chairman ANDERSON. If they have not liked it thus far and do not have any program for moving into it, the probabilities are that if they could not get but 150,000 at the time they were going to have a million, and the demand is gradually growing less because of the presence of these fossil fuels and the development of oil and natural gas in northern Africa, we are not going to have any sudden rush before this.

Mr. FLOBERG. That is certainly true.

Chairman ANDERSON. I remember that just a year ago the New York newspapers printed a headline reading "Europeans Score U.S. Atom Accord, Six-Nation Nuclear Pool Seeks Stronger Guarantee on Fuel-Fabricating Costs."

If they did not need the rather weak guarantee we got because of the industrial guarantees, why would they need a stronger guarantee?

Mr. FLOBERG. I do not know what the source of this information was, but obviously they wanted whatever they thought they could get. This rumor undoubtedly came from the utility people themselves.

There was never any serious consideration within the Commission of stepping up the level of the fuel element guarantees. We thought that the fuel element guarantees were well founded but optimistic.

It turned out that that particular prophecy has worked out pretty well in connection with Euratom. Most of the others were not so good.

Chairman ANDERSON. I did not mean to say that the Commission was trying to raise the fuel guarantee. This was a group of Europeans who were trying to raise it. Only because the industrial guarantee was beyond what was contemplated, they wanted something beyond that to be paid for by the country.

It seems to me that this has worked out so that very little of this money would be needed, and I think gives a good deal of moral backing to the development of additional types in this country, which I am glad to say seems to be coming along.

Mr. FLOBERG. The situation in India and Japan differs somewhat from that in Europe. Both of these nations believe that nuclear power may be economic or nearly so in some of their high-cost areas at the present time.

India is studying a nuclear power program which might be incorporated in its third 5-year program and has held discussions with us on their plans. They plan to solicit this year on a worldwide basis bids for a 250-mwe. reactor to utilize natural uranium.

Japan has contracted for a full-scale reactor of the Calder Hall type, is negotiating a contract for the purchase of a boiling water prototype reactor of 12 mwe., and is reported to have an interest in a large-scale reactor of the water-moderated type.

While these activities are encouraging, we believe it is still too early to predict to what extent and on what time schedule substantial nuclear power programs may get underway in either of these countries.

The nuclear power program of the United Kindom is approximately on their current schedule of obtaining 5 million to 6 million kilowatts' capacity by 1966.

On the Chairman's recent visit to the Soviet Union, he learned that the U.S.S.R. will install only the first of the two reactors planned for the Voronezh nuclear power station and only two of the four scheduled for Beloyarsk. Also, the Leningrad nuclear power station apparently will not be constructed until the first reactor at Voronezh has been operating.

Thus, stretchouts from their 1955 and 1958 construction plans are apparent, as I am sure some members of the Joint Committee learned on their trips to the Soviet Union.

As far as we know, the U.S.S.R. dual-purpose reactor program is not involved in these stretchouts. I should note, also, that four reactors in the 5- to 50-mwe. range are to be built at Ulyanovsk; the site is now being prepared for these reactors and they are to be completed in 1962–64.

The U.S.S.R. is reported to be building a 97-mwe. nuclear power plant for Czechoslovakia and a 70-mwe. powerplant in East Germany, expected to go into operation in 1963–65.

Mr. RAMEY. Does this indicate that the Russians have a diversified program like our own, that they are following more for demonstration purposes than necessarily to achieve early economic power?

Mr. FLOBERG. Certainly the last half of your statement is correct. I would amend the first half to say that they are diversifying their program rather than having a diversified program. They were more concentrated and now are in the process of diversification.

Mr. RAMEY. Actually the examples of the cutbacks you give, they were additional reactors of the same type?

Mr. FLOBERG. That is right.

Mr. RAMEY. So they would learn from a developmental standpoint presumably as much from two as four. That would be just kilowatts. Similar on the Voronezh, if you build one pressurized water type, you would not necessarily have to build another to learn.

Mr. FLOBERG. I think that is correct. I think they want to try these out on a operational basis, and then if they are working out all right they will continue with the other or they will make such modifications in the followup portions of those plants as necessary.

I think it does indicate that they are not in as much of a hurry to get this particular power as they maybe thought they were a short time ago.

Mr. RAMEY. Or to get kilowatts. But they might be getting as much technical knowledge and catch up to us or beat us technically as they did before.

Mr. FLOBERG. I am sure they intend to get as much technological knowledge out of these projects as they possibly can. There is no question about their intention to do that.

Representative WESTLAND. I would like to ask, in your opinion, is any country putting in the time, money, men, and materials that this country is putting in today?

Mr. FLOBERG. In my opinion, the answer to that question is no, but I do not know if we have ever considered it in just that context.

Representative WESTLAND. That is why I asked the question.

Mr. FLOBERG. I am pretty familiar with all the European programs.

Representative WESTLAND. Those are the only other countries?

Mr. FLOBERG. The United Kingdom should be considered in connection with that. I would let the chairman comment on that. He knows the United Kingdom program better than I do.

Chairman ANDERSON. I think it is important to point out that in your own statement you point to 5 million to 6 million kilowatts capacity in the United Kingdom by 1966. Will we have anything like that?

Mr. FLOBERG. Not in terms of kilowatt capacity. Certainly not. A good many of these plants are duplicates of previous technologies or in some cases there is more than one reactor of identical technology at a particular site.

Chairman ANDERSON. I think that is why the answer is a little difficult, if any other country is putting in as many men and materials. We are putting it in in a better way for a diversified program even though we do not have as many men or money in it.

Representative WESTLAND. I realize that. I asked the question on the actual production of kilowatts because I recognize that different conditions prevail in other areas. I did ask the question whether or not any other nation is putting in the time, money, men, and materials devoted to nuclear energy that this country is putting in.

Mr. McCone. I would like to comment on that question, if I may. In the first place, I agree with what you said concerning the United Kingdom. They have a large effort for the production of kilowatts. The plants are all substantially alike.

They are a plant that we feel would not meet our criteria of competitive power in this country, although they are very useful for reasons that this committee understands in Great Britain. They are doing a considerable amount of research on advanced and high-temperature, gas-cooled reactors, and I think Admiral Rickover will comment on that a little later because he has all of the current information.

It is very difficult to measure and compare the effort in the Soviet Union with that of the United States, but it was our conclusion that their effort in their laboratories in research and development and in experimental reactors and so forth was quite comparable in the magnitude of the effort with our own.

We visited on our trip all of the major laboratories. We felt that in terms of the number of scientists and the number of technicians, they have an impressive effort and an effort that is comparable to ours.

With respect to their plants, they obviously have found that the technical problems and the costs of nuclear power were much greater than they expected. Khrushchev went into this in considerable detail with the President. Emelyanov spoke to me about it a number of times when I was there and when he was in the United States.

For that reason they have done, as Mr. Ramey intimated in his questions, diversified and are probing a number of different processes, such as we are, hoping to find the one that will be most productive from the standpoint of giving them dependable and economical nuclear power.

They point out that they are expanding their coal resources. They are producing coal more cheaply than they were. They are depending more and more on fossil fuels rather than looking to nuclear power to meet their own requirements. They also indicated that they find hydroelectricity is quite expensive from the standpoint of capital costs, and therefore, they are reconsidering some of their hydroelectric programs.

They seem to be leaning toward the fossil-fuel program.

In general, we were satisfied that we were well ahead of them. However, as I have said on many occasions, they were doing some things that were very impressive and we did not leave the Soviet Union with a feeling that their progress should be ignored by any manner of means.

They have an ability to concentrate their attention on certain things that they consider important and to get them done with remarkable rapidity. That was one of the greatest lessons I learned from going over there.

Chairman Anderson. I want to say that I think we are very fortunate that you did go over. One of the interesting things to me that your fellow Commissioners may not know—Professor Emelyanov

told me that the first time he had ever been down in a uranium mine is when Mr. McCone got to Russia and wanted to go down inside one.

He felt as host he had to go. He had never gone into one before. I think that is just a sample of the good results of visiting around. You get to see a lot of things. I appreciate that statement by the Chairman.

Representative HOLIFIELD. Mr. Chairman, this paragraph 121 is in the first person, and as I understand your statement, Mr. Floberg, it was read for the Chairman; does this indicate that the national objective has now changed from what we would consider a brisk, if not a crash, competitive program to keep ahead of the Russians in this field from the standpoint of the international prestige that would be involved in early acquirement of an economic reactor?

Has the administration's attitude now changed to one of saying, "Well, the Russians are not doing anything unusual, and therefore we can slow up over here and it is no longer necessary for the Government to go ahead with an aggressive program in this field as was once advocated before this committee"?

Mr. MCCONE. There are several parts to that question.

In the first place, I feel and the Commission feels that the program we outlined yesterday is an aggressive, a brisk, and a sound program, and a proper one to reach our goal of dependable and economic nuclear power as rapidly as is possible in light of the technological problem.

That program was not in any way designed or influenced by our observations of the Soviet program. On the other side of the coin, I think that the Soviet program might be accelerated a little bit in the light of what they saw that we were doing.

They expressed extreme interest and a great desire to have a Dresden plant, for instance, and a Fermi plant. The last thing that Professor Emelyanov told me, he said he thought he would have to build an aqueous homogeneous experiment because he was so impressed with what he saw at Oak Ridge.

Their eyes were opened from what they saw in this country. I think our program has not been influenced by them. We have a program that was designed to meet our objectives aggressively and with due consideration of the technological problems that must be solved. It was not influenced by the programs of any other country.

Representative HOLIFIELD. We were repeatedly told that the reason for the Government entering into this atomic power program in an aggressive manner financially was not because we needed atomic power here at home. We have plenty of fossil fuels and hydroelectric power, and so forth.

But it was because we might be faced some day with a tremendous achievement on the part of the Soviets, which would give them an entering wedge into the have-not power nations of the world from an industrial standpoint, followed, of course, by their ideology.

I think many of us on the committee have thought an aggressive program should be waged—a very aggressive program—for that reason, and not because we needed it here in the United States. If paragraph 121 is taken on its face, and if we rest on that assumption, it seems to me that there is very little need for the Government to

continue to subsidize an atomic energy effort in the United States, and that we might save a lot of money and allow this industry to proceed as other industries have proceeded without Government help and Government subsidy.

If we are going to go on the assumption of paragraph 121, and if we take this at its face value and if we ignore the fact that there may be some Soviet projects behind the curtains, they have a habit of doing these things, you know. Suddenly we may be presented with a sputnik or we are presented with a picture of the moon and it becomes a tremendous propaganda weapon for them throughout the uncommitted world.

Are we taking this risk knowingly, that they may be doing the same thing back in the Urals by the development of a more advanced atomic energy program and we are discounting the fact that this might be true, and we are willing to discard any thought that they might, and therefore we should adjust our program to a more leisurely pace?

Mr. McCone. In the first place, we can only report to you, or I can only report to you what I saw, and what I was told.

Representative Holifield. That is right.

Mr. McCone. Just as you can report to me what you saw and what you were told.

Representative Holifield. That is right.

Mr. McCone. Neither of us can guarantee that they did not hold out and that there was not some spectacular development going on at some laboratory that we knew nothing about. That would be a very serious risk if we were to gear our program to what we were told and what we saw.

However, we are not doing that. Paragraph 121, which you referred to, has in no way influenced our program either with respect to the long-range program I outlined yesterday or to the authorizations we will request from you or the appropriations we are going to request.

Representative Holifield. But if we accept it at face value, it does lull us into a feeling that what we are doing is more than what they have showed us, and therefore we are going at a pace that is fast enough and there is no need for us to fear any secret operations of theirs which may be designed to some day face us with a fait acompli.

Mr. McCone. I urge you, Mr. Holifield, not to place this interpretation on this paragraph. There is a danger that this paragraph as written would lead this committee to this impression. For that reason it would diminish the enthusiastic support that you have had and the committee has had behind the effort to accomplish the goal of nuclear power.

Then I would like to amend the paragraph because that is not the purpose. We want your continued and enthusiastic support of this effort.

Representative Holifield. I understand that. But this does put me in the position, if we are going to gage the Soviet effort by that which we know or which they have revealed to us, then I feel very comfortable. I do not feel necessarily like putting several hundred million dollars into the reactor program.

In other words, we have nothing to worry about. Let us just go ahead and let private enterprise develop atomic energy like they did the automobile and some of these other things. But on the other hand, if there is a chance that the Soviets will face us suddenly some day with a "picture of the moon" type of reactor and say "We are ready now to export to underdeveloped nations 5-mill atomic power reactors," I ask you what position we would be in at that point.

Mr. McCone. You went through the Atomic Energy Institute in Moscow, didn't you, with Professor Alexandrov when you were there?

Representative Holifield. No; but I know about it. I was down at Rostov going through an agricultural plant that day.

Mr. McCone. If you had gone through there and seen their effort in the laboratories, you would not for 1 minute relax on this. You would keep the effort up. The policy or the feeling that nuclear power will become an important instrument in our international policy remains unchanged.

It has been more difficult to develop it. Small nuclear powerplants have not been able to produce economical power, although we are building one that looks a good deal better than anything we saw here before. This continues to be an objective, and one of the reasons behind the program.

We are not advocating the program that was outlined yesterday to this committee solely on the basis of the international aspects. We must in this country look forward to diminishing fuel supplies in certain areas and higher cost fuels in certain areas.

The one area in particular being the State that you and I both come from. We have to look forward to that, and therefore it is important to equip ourselves with an alternate source of energy.

Representative Holifield. I recognize the importance of it being a new source of energy certainly. I thought that for many years. I am talking about the degree of urgency that is involved. If I am not to worry about anything happening behind the Urals in the reactor development program which we have not been told about, then I am going to approach the whole problem in a more leisurely fashion.

I am going to be a little bit more careful about spending Government money to develop these reactors. I am going to look at each one of these programs a little more carefully because if we are this far ahead of them, as is shown here, and they are not concentrating as you have so often, and I think, fairly pointed out, on a project to get something done quickly for propaganda or political reasons, if they are not doing that behind the Urals, I am going to feel much better.

In these days of budget balancing, I might even help the President budget the balance on this program.

Chairman Anderson. That will be the day.

Representative Hosmer. Mr. McCone, as long as the question has come up, did you or any of your colleagues ever, over the past 5 years, have in mind coming up with what might be termed a "picture of the other side of the moon" type reactor, something fantastically cheap in relation to what we have on the boards or under way at the present time?

Mr. McCone. I think from time to time people who have been involved in this business have thought that there was a possible breakthrough and as a result there would be developed a process to produce power from nuclear energy that would be remarkably cheap. There have been a great many statements made to that effect.

Representative Hosmer. I know, but I am talking about the Commission itself.

Mr. McCone. The Commission at the present time do not see anything other than hard, tough, and costly work in solving the technological problems that must be solved to bring about the goal which we outlined yesterday.

Representative Hosmer. As a matter of fact, even if you can produce electrical kilowatts for nothing, there is still a great deal of cost involved in ultimately getting them to the user. Isn't that true?

Mr. McCone. Of course that is true. The production of the kilowatt-hours is only one part of it. The distribution and the arrangements for the consumption, of course, is a great part of any electrical system.

Representative Hosmer. In that light, isn't it unrealistic to expect that we will ever, even under the most optimistic circumstances, create a device whereby power could be brought to these undeveloped nations at anything less than fairly substantial capital investment costs?

Mr. McCone. Yes; that is true. Any source of electrical energy involves distribution arrangements and arrangements for consumption of the power which will be substantially the same. Therefore, what we are talking about is the generation cost, the cost of the power at the distribution point from the plant itself.

This is only a relatively small part of the total power cost to the consumer.

Representative Hosmer. Realistically you cannot anticipate that the Iron Curtain countries or ours, no matter what miraculous generating device we came up with, could thereby change the general power picture to any real extent. Is that a fair statement?

Mr. McCone. I would like to appraise the overall distribution costs of a complete power system or a theoretical power system to answer that question. It is my belief that lower production costs of power, and particularly in small units, will have an important effect on the power economy of countries, particularly those who are just beginning to build up their power load, such as India.

Representative Hosmer. And the most fruitful area is in connection with the small power units rather than large central power stations.

Mr. McCone. From the standpoint of areas of the world outside of the industrialized European nations, Japan and the United States, this is true.

Representative Hosmer. That is all.

Chairman Anderson. Very well, Mr. Floberg. Will you proceed?

Mr. Floberg. Our testimony, of course, has reviewed only a portion of our international atomic activities—those related to nuclear power. We are lending every assistance to the study on international activities in atomic energy being carried out for this committee by Mr. Robert McKinney. We will be interested in the results of this study.

Mr. Floberg. Now, on the subject of industrial activities, in considering the development, growth, and state of the atomic energy in-

dustry in the United States, we are glad to report that the industry continues to grow.

124. An index of this growth is to be found in the most recent Joint Commission-Bureau of Census annual survey of shipments of key atomic energy products from private manufacturing establishments during 1958. It showed a 55-percent growth in such shipments over 1957.

125. The heaviest industrial impact of atomic energy work comes, of course, from construction of nuclear reactors. Data based on a quarterly Commission survey indicate civilian and military reactor projects under construction or active development as of September 30, 1959, including both Government and private projects, represented total commitments of more than $1.7 billion. This figure includes about $320 million for research and development work directly related to specific reactors.

126. Let me make clear that the survey on which these figures are based covers only projects which actually are under construction or active development, and excludes projects already completed, such as Shippingport, and projects announced as planned but which are not yet in design stages.

127. About $1 billion of the $1.7 billion total is for civilian projects, the remaining $700 million for military projects. Propulsion reactors for naval vessels account for about two-thirds of the military total. The bulk of the money still remains to be spent. We believe this represents a conservative estimate of the level of reactor activity, since the dollar figures do not include projects for propulsion of aircraft, critical experiments, small training reactors, and general research and development work.

128. Eighteen reactor experiments and prototypes directed toward production of economical nuclear power accounted for $717 million. The Commission's support totaled $252 million, and electric utilities were financing $465 million.

129. The Commission, under the provisions of the Atomic Energy Act, has a responsibility to encourage widespread use of atomic energy in such a manner as to strengthen free competition in private enterprise.

130. From its inception the Commission has turned to private industry to construct its facilities, and to industrial companies and educational institutions for their operation.

131. It continues to be Commission policy, announced first in 1956, that the Commission will cease to provide any service or product to the public whenever they can be provided under reasonable terms by private industry.

132. The Commission has maintained a firm policy of procuring goods and services from private industry wherever practical.

133. As you know, there has been discussion recently regarding the Bureau of the Budget Bulletin 60–2, issued last September in modification of previous bulletins on the same subject. This bulletin states that generally the Federal Government should not start or carry on any commercial industrial activity to provide a service or product for its own use if they can be procured from private enterprise through ordinary business channels.

134. We received letters from industrial groups asking that we review certain of our activities from the standpoint of the Bulletin. Our response to industry has been placed before this committee.

135. During 1959, the Commission took further action to increase private participation in atomic energy work. For example, it continued efforts to procure fuel fabrication and processing services from private firms wherever possible. As a result, Commission contracts for such service valued at about $40 million were let during the year.

136. The Commission also increased use of private facilities for recovery of unirradiated scrap.

Chairman ANDERSON. I think, Mr. Floberg, that we will put into the record the material which we received or which was released to the press on Friday, February 12, which was the full responsibility. I do not want to have to read it, but I think it is a good answer and ought to be put in the record.

(The information referred to follows:)

(NOTE TO EDITORS AND CORRESPONDENTS.—Attached for your information is a letter of the Atomic Energy Commission to the Chamber of Commerce of the United States, the Manufacturing Chemists' Association, and the National Association of Manufacturers in reply to communications from these organizations concerning the Commission's application of the Bureau of the Budget Bulletin No. 60–2 on "Commercial-Industrial Activities of the Government Providing Products or Services for Governmental Use.")

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., February 10, 1960.

CHAMBER OF COMMERCE OF THE UNITED STATES,
COMMITTEE ON COMMERCIAL USES OF ATOMIC ENERGY
(Attention: Jack H. Abernathy, Chairman).

NATIONAL ASSOCIATION OF MANUFACTURERS,
NUCLEAR ENERGY COMMITTEE
(Attention: J. F. Fairman, Chairman).

MANUFACTURING CHEMISTS' ASSOCIATION, INC.
(Attention: R. C. Johnson).

GENTLEMEN: Your letters which submitted examples of Commission activities which you believe may constitute competition with industry within the meaning of Budget Bulletin 60–2 cover to a great extent the same activities. For this reason, a single reply seems appropriate.

In carrying out its statutory responsibility to encourage widespread use of atomic energy in such a manner as to strengthen free competition in private enterprise, the Commission has maintained a firm policy to procure goods and services from private industry wherever practical. From inception the Commission has turned to private industry to construct for the Government the major facilities required for the production of fissionable materials and for the comprehensive research and development program contemplated by the Atomic Energy Act. Government ownership of such facilities was found to be essential, since no reasonable way could be found to provide adequate incentives for private ownership of such specialized and costly facilities.

Further, as a means of utilizing and expanding the skills of the entire national economy and to take advantage of know-how and proven business experience, the Commission engaged industrial companies and educational institutions to operate and manage these facilities.

The continued use of existing Government facilities is clearly necessary in the public interest for the production of fissionable materials, the assembly of weapons, and the conduct of most advanced research and development. The facilities and skills of private industry are and will be employed when they are adequate to carry out specific activities in the military and peaceful applications of atomic energy at the rate required to attain our national objectives. It should be emphasized, however, that the Commission must exercise care in discontinuing a specific activity to assure that related actvities which are closely integrated do not unduly suffer in development, cost, or efficiency by reason of the divorcement.

In this new industry, the tempo of technological developments in many instances does not permit establishing precise specifications or assure a volume of repeat orders necessary to attract the investment of private capital in the specialized facilities, equipment, and personnel required. Consequently, there still remain areas of the Commission's work where it is premature to expect that such work can be procured from private industry on a competitive basis. Furthermore, we have a responsibility to avoid the concentration of services with a single source of supply, particularly under circumstances where such concentration might constitute a preemption of the market which would discourage widespread participation in the uses of atomic energy.

We recognize that as the atomic energy industry grows, there will be areas of activity appropriate for transfer from Government to private operation. Numerous products and services formerly provided exclusively in Government facilities are now procured commercially, major examples being fabricated beryllium shapes, hafnium and zirconium products, uranium hexafluoride, and fuel elements for many nonproduction reactors. It is Commission policy to contract with private firms for the performance of title I and title II engineering of both nuclear and nonnuclear portions of the plant, unless the nature of the work and the circumstances clearly dictate otherwise. Also, it is Commission policy, announced in 1956, that the Commission will cease to provide any service or product to the public whenever such service or product can be provided under reasonable terms by private industry.

The examples presented in your letters are concerned, in large measure, with specific activities within a production or research and development complex. Many of these activities have been carefully studied over a period of years for feasibility of separate contracting. A major reason for contracting with industrial concerns was to have our facilities operated in accordance with sound and proven business practices. Such business practices include procuring goods and services from specialized concerns wherever such concerns can satisfactorily furnish the product required and when to do so is sensible, economical, and consistent with the efficiency of integrated operations.

A typical example of the practices applied is contained in the following statement of policy of one of our major industrial contractors:

> The determination of the method by which these services will be performed is made in accordance with normal private industrial criteria, modified to the extent necessary to comply with existing AEC directives and applicable Federal law.
>
> These criteria include, but are not necessarily limited to, the following:
>
> (1) *Costs.*—By what method and by whom can the service be performed at the least possible cost?
>
> (2) *Relationship to the manufacturing process.*—How dependent is the process on the service being studied? Would an interruption in the service have a serious detrimental effect on the process?
>
> (3) *Availability from commercial sources.*—Is the service available commercially at a competitive price? Is there sufficient productive capacity in commercial sources to assure delivery of needed quantities? Is the geographical location of the source or sources an advantage or disadvantage?
>
> (4) *Volume of work.*—Is the volume sufficient to make it feasible for contracting?
>
> (5) *Security requirements.*—What effect do the related security requirements, if any, have on the method of performing the service?
>
> (6) *Developmental aspects.*—Is the design of the material or service sufficiently clear so that it is possible to contract without excessive cost?
>
> (7) *Contamination.*—Is the material contaminated above limits which can be released to commercial sources?

As applied to the Commission's operations, such typical business criteria are supplemented as applicable by other Government criteria such as those contained in the recent Budget Bulletin 60–2. Such supplementation provides, for example, that the elements of cost as provided for in Budget Bulletin 60–2 be considered in making comparisons between the cost of providing services at the Government-owned plant and the cost of procurement from commercial sources. Furthermore, our contractors are specifically advised of activities where it is Commission policy to subcontract to private industry. It is our practice to make surveys and appraisals of operations at Government-owned installations to review the continued application of these criteria. By effective application of such criteria, evidenced by thousands of contract actions annually for research, engineering,

construction, equipment, and supplies, a wide range of enterprise in the atomic energy industry is being developed.

For each of the activities cited as examples in your letters, we have prepared comments which are attached. Many of the examples are in areas of future activities in which we look forward to either initial or increasingly greater industrial participation on a commercial basis, while others generally fall into the following categories:

(1) Activities where industry is already engaged in the normal conduct of the work.

(2) Activities which are closely integrated with plant operation and in accordance with accepted industry practice should remain integrated.

(3) Activities which are in such a fundamental stage of development that the coordinated use of the skill and facilities at Government-owned installations is still required.

(4) Activities where large volume is dependent upon military requirements and where extremely large plant investments have already been made by the Government, or where the volume of activity is so small, sporadic, and nonstandardized as to make it impractical or uneconomical to contract for separately.

(5) Activities for which there is no known competitive commercial capacity.

We trust that this letter and our attached comments on the examples you have cited will provide a better understanding of the Commission's policy and practice regarding the utilization of private enterprise in fulfilling its responsibilities under the Atomic Energy Act. We will continue to examine commercial-industrial activities of the Commission in the light of the growing capability in the private atomic energy industry. For this purpose we will welcome at any time expressions from industry of their capability to provide additional services and products through ordinary business channels.

Sincerely yours,

JOHN F. FLOBERG, *Acting Chairman.*

(Attachment to the Commission's reply to the Chamber of Commerce of the United States (C. of C.), the Manufacturing Chemists' Association (MCA), and the National Association of Manufacturers (NAM): Comments on AEC activities cited as examples of competition with industry within the scope of Bureau of the Budget Bulletin No. 60–2)

I. FUEL ELEMENT DEVELOPMENT AND FABRICATION

A vital part of any reactor is the fuel element with which it operates; the success or failure of a particular reactor experiment, prototype, or power reactor depends strongly upon whether a suitable fuel is available. Just what constitutes a suitable fuel depends upon the purpose of the experiment. Thus, in a zero power reactor the composition, weight, dimensions, and uniformity of the fuel are of controlling importance; resistance to irradiation damage is of very little interest. On the other hand, fuel for a high-temperature, high-burnup reactor must have a high degree of irradiation stability. Thus, the fuel must be tailored to fit the experiment. The fuel itself is experimental in nature. In the continuing effort to improve the fuel, successive loadings of the same experimental reactor are usually different, each type of loading being used only once. The Commission carries on an extensive program in the development of suitable fuel elements; this work included the development of fuel and cladding materials; the determination of their physical, mechanical, and thermal properties, and their behavior under irradiation and thermal cycling; and development of methods of melting, casting, fabrication, and testing.

This program is so broad that it involves not only most of the Commission's laboratories and operating contractors but also a very large portion of the program is being conducted by commercial firms. In an action announced March 13, 1959, contracts with contemplated expenditures totaling over $25 million were awarded to 18 firms.

Outside of purely experimental tasks which must be closely coordinated with other development work, it is the Commission's general policy to obtain fuel element manufacturing services, other than for the production reactors at Hanford and Savannah River, from commercial sources. Our general policy is to procure reactor materials from commercial suppliers whenever adequate

facilities, skills, and experience exist in commercial laboratories and the time schedule can be met. In addition, whenever it is feasible, we are now procuring end items containing nuclear materials rather than separately procuring materials and fabrication. The ability of industry to produce according to requirements has increased very appreciably in the last 5 years or so, and more and more of the requirements are being met from industrial sources.

To illustrate the extent to which procurement from commercial sources has progressed, there follows a tabulation of the enriched uranium which has been furnished to all sources outside the weapon's production chain, showing the proportion furnished in the form of UF_6 compared to that furnished in a form requiring additional processing in AEC facilities:

Fiscal year	Total (kilograms)	Furnished in form other than UF_6		Furnished as UF_6	
		Kilograms	Percent of total	Kilograms	Percent of total
			Percent		*Percent*
1958	45,000	21,000	47	24,000	53
1959	116,500	6,500	6	110,000	94
1960 (5 months through Nov. 30, 1959)	42,500	1,500	4	41,000	96

Comments on specific cases mentioned in the letters follow:

EXPERIMENTAL GAS-COOLED REACTOR

C. of C. VI–1: "Enriched uranium and/or pellets for the gas-cooled reactor project at the Oak Ridge National Laboratory."

MCA–5: "Enriched uranium oxide and/or pellets for the gas-cooled reactor project at ORNL."

NAM–A1b: "Supply of enriched uranium oxide, pellets, or metal for gas-cooled reactor project; * * *."

Oak Ridge National Laboratory (ORNL) is currently preparing the design and specifications for the fuel element and materials so that the core loading can be procured from industrial sources following normal procurement practices. In the development of this element, ORNL has attempted to procure from industrial sources enriched UO_2 and/or UO_2 pellets which meet its specifications. Experience to date has been disappointing in that ORNL has been unable to obtain the necessary quantities of acceptable materials. The yields have been disappointingly low, the schedules have had to be changed at the convenience of suppliers, and in all cases ORNL has obtained the pellets it required only by relaxing the specification.

PROCESS HEAT REACTOR

C. of C. I–2: "The conversion and fabrication of fuel elements for the process heat reactor project to be built at Point Lomas, San Diego, Calif."

MCA–4: "Conversion and fabrication of fuel elements for the process heat reactor project to be built at Point Lomas, San Diego, Calif."

NAM–A1a: "Conversion from UF_6 * * * for process heat reactor to be built at Point Lomas, Calif."

The invitation to reactor manufacturers to supply the reactor and certain primary system components included all of the internals and the reactor core with 14 percent spares. This invitation was issued in October 1959, and a number of proposals from manufacturers had been received and were being evaluated when the letters to which this reply is addressed were received. All of the fixed-price proposals received contemplate commercial supply of these fuel elements by the selected proposer. The Commission is supplying UF_6; all other services will be obtained commercially.

BULK SHIELDING REACTOR AND LOW-INTENSITY TEST REACTOR

C. of C. I–1: "The Oak Ridge National Laboratory makes the fuel elements for most of its reactors. Examples include the bulk shielding reactor and the LITR."

Private sources of supply for procurement of replacement fuel elements for the LITR and BSR are not used for the following reasons: The demand for these elements, based on data accumulated during the past 5 years, indicates the following average yearly requirements: LITR, 15 elements; BSR, 5 elements. The number of replacement elements is low because of the low power at which these reactors operate. (The BSR operates from zero to 100 kilowatts and the LITR at 3 megawatts.) Since the BSR and LITR are used to test experimental fuel assemblies, about 25 percent of the replacement fuel elements are not standard. Dies and fixtures are available for these specific elements so that the small number required can be produced by laboratory staff as "fill-in" work.

MATERIALS TESTING REACTOR AND ENGINEERING TEST REACTOR

MCA–7: "Supply of enriched uranium for ETR and MTR fuel elements."

NAM–A1b: "Supply of enriched uranium * * * metal for * * * ETR and MTR at Arco, Idaho * * *."

The original MTR fuel elements were fabricated at Oak Ridge prior to availability of commercial sources. The first MTR replacement also was the first core for an AEC reactor to be obtained from a commercial fabricator. Since then, all cores have been fabricated commercially:

Materials Testing Reactor:
- Replacement quantity 1[1]: Babcock & Wilcox.
- Replacement quantity 2[1]: Clevite.
- Replacement quantity 3[1]: General Electric.

Engineering Test Reactor:
- Original quantity: Babcock & Wilcox.
- Replacement quantity 1[1]: General Electric.

While the Government furnished metal in each of these cases, the statistics previously cited indicate the effectiveness of AEC's efforts to obtain the processing services from commercial sources. In the most recent case (MTR replacement No. 3) the invitation requested proposals on both bases (i.e., use of commercially procured metal or use of Government-furnished metal). The decision to use Government metal was based on the price differential analyzed in accordance with BOB Circular 57–7 (the predecessor to BOB Circular 60–2).

NUCLEAR ROCKET PROGRAM—PROJECT ROVER

C. of C. I–3: "The conversion and fabrication of the fuel elements for the nuclear-rocket program (Project Rover)."

MCA–6: "Conversion and fabrication of fuel elements for the AEC's nuclear rocket program at Livermore."

NAM–A1a: "Conversion from UF_6 and fabrication of fuel elements for AEC nuclear rocket program at Livermore; * * *."

Responsibility for all research and development for the nuclear propulsion of rockets (Project Rover) is assigned to the Los Alamos Scientific Laboratory. Enriched uranium metal for Rover fuel elements is drawn from the inventory maintained at Los Alamos for the weapons program, and fuel element fabrication work is performed in the same facility in which development of uranium fabrication techniques is carried on for the weapons program. The material for Rover is a relatively small proportion of the amount fabricated in that facility.

At present, every Rover reactor is different. Fuel elements requirements and technology are still in development, and cannot yet be described by definite and inclusive specifications. In view of the frequent and last-minute changes in design details and characteristics to be sought, fuel element fabrication for the current, research-type Rover systems must continue as an activity performed directly by the Los Alamos Scientific Laboratory.

At later stages when there are repetitive tests of a single design, the degree of standardization may permit commercial procurement of both the conversion and fabrication of uranium for Rover fuel elements.

NAVAL REACTORS

C. of C. III–1: "Conversion of enriched * * * uranium from UF_6 as required in the 'Nuclear Navy' for metal, alloys, or uranium compounds."

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[1] One year's supply.

MCA–1: "Conversion of all enriched uranium from UF_6 as required in the 'Nuclear Navy' for metal, alloys, or uranium compounds."

NAM–A1b: "Supply of * * * all uranium alloys or compounds for the 'Nuclear Navy.'"

Practically all of the highly enriched uranium utilized in these cores is obtained from scrap metal in the form of trimmings left from material utilized in the weapons program. These trimmings are chopped into small pieces and shipped to the core manufacturer who performs all further processing and fabrication operations involved in the manufacture of the fuel elements.

There are now five private companies supplying reactor cores for the naval reactors program on a fixed-price, competitive basis. Through calendar year 1959, contracts totaling approximately $200 million have been awarded to private industry for fuel fabrication.

These companies now manufacture all reactor cores for the naval reactors program with the exception of some first reactor cores of a type which are of a highly developmental nature. However, many of the parts, even for these first developmental cores, are manufactured by private industry rather than in the Commission's Bettis and Knolls Atomic Power Laboratories. In this connection, it is also significant that a substantial portion of these parts for developmental cores which are subcontracted to private industry are in themselves of a developmental nature. This type of subcontracting from the Bettis and Knolls Atomic Power Laboratories to private industry has been increasing, commensurate with industry's capability to handle such work. Thus, the fuel fabrication work that remains in these laboratories is only that which is of a highly developmental nature and pertains specifically to the first core of a new design being developed at the laboratory.

SUBCRITICAL TRAINING REACTORS

MCA–12: "Conversion and fabrication of uranium elements required for subcritical training reactors for educational institutions."

NAM–A1a: "Conversion from UF_6 and fabrication of fuel elements * * * for subcritical training reactors * * *."

Educational institutions, as of January 1960, possess or are planning to acquire 2 enriched uranium and 84 natural uranium subcritical training reactors. The fuel is furnished by the AEC without charge to the institutions. The enriched fuel is fabricated commercially and the natural uranium fuel is furnished by the AEC from its supply of reject slugs at Savannah River. It is anticipated that in the next several years educational institutions will require approximately 25 new subcriticals per year.

Since these are vital to the educational programs on which both industry and Government must rely for new trainees for this expanding industry, it is desirable to provide the facilities so that the greatest number of training programs can benefit. Use of material which does not meet the production reactor specifications is a suitable and economical means of increasing the effectiveness of the training program.

NUCLEAR RAMJET PROJECT

C. of C. VI–2: "Enriched uranium for the nuclear ramjet project."

On the original order for fuel for the Tory II A, the conversion from UF_6 to U_3O_8 was performed by the Commission's Oak Ridge Y–12 plant. Y–12 was used for this job on the basis of a technical evaluation of capability. Because of the unique and stringent chemical specifications for the U_3O_8, it was determined that no source other than the highly experienced Y–12 plant could be reasonably expected to perform this conversion job on the required schedule and at an acceptable cost. It is anticipated that future requirements for conversion of UF_6 and the fabrication into fuel materials will be obtained commercially, providing that commercial capability exists to provide these services at reasonable cost and upon the required schedules.

PIQUA AND HALLAM REACTORS

MCA–13: "Production of enriched uranium metal for the Piqua and Hallam reactors."

Present plans for both the Piqua and Hallam reactor projects are that the fuel conversion will be done commercially. Fabrication in both cases will be by Atomics International, the AEC prime contractor for construction of the reactor. In both cases, arrangements have not yet been completed.

HEAVY WATER COMPONENTS TEST REACTOR

MCA 11: "Production of uranium for heavy water component test reactor being built at Savannah River."

C. or C. I–4: "Savannah River is also doing fuel element development work. This includes the conversion and fabrication of fuel elements for the fuel element heavy water test reactor being built at Savannah River."

NAM–A1a: "Conversion from UF_6 and fabrication of fuel elements for heavy water components test reactor at Savannah River."

The driver and fuel elements for the HWCTR are not being manufactured at the Savannah River plant. This work is being carried out in commercial facilities, Nuclear Metals, Inc., Concord, Mass., under a Du Pont subcontract. The contract for this work was awarded after a survey of six fuel element manufacturing concerns which appeared to have the experience and facilities for making tubular metallic fuel elements. In the case of the driver tubes, the small number required resulted in little interest by industry in this operation. It was indicated, however, that should significantly larger numbers of tubes be required, industry would be interested in submitting bids. In the case of the HWCTR fuel elements, these are still in the development stage. Considerable development work and testing are required before establishing a firm design for this element. Nuclear Metals has been engaged to do much of the development work and to supply the necessary test elements during the development period.

SAVANNAH RIVER AND HANFORD PRODUCTION REACTORS

C. of C. I–4: "The Savannah River site makes some fuel elements for its reactors. Savannah River is also doing fuel element development work."

C. of C. I–5: "Fuel elements for the Hanford site are fabricated in Government facilities."

The manufacture of fuel elements for production reactors has been accomplished in Government-owned facilities operated by industrial contractors since the initiation of production activities during World War II. As the AEC program expanded, additional capability was provided to meet the increased requirements. The current operating facilities at Fernald and Weldon Spring represent a Government investment of about $165 million. These facilities are operated by industrial companies under cost-type contracts.

There is no privately owned industrial facility in being which can meet the requirements of the production program. It is not considered feasible to contract for production reactor fuel element fabrication in privately owned facilities at fixed prices, chiefly because of the frequent and substantial changes which are required in fuel element types, specifications, and quantities resulting from new conditions in the production reactors. The operation of fuel fabrication plants must be closely integrated with production reactor operations and thereby with weapons production schedules. In order to accommodate new operating requirements without delay, any fixed-price arrangement with a private supplier would necessarily involve price renegotiation to offset changes in costs as requirements change. Such an arrangement would approach closely a cost-type contract similar to those which now exist between the companies operating AEC's fuel fabrication facilities and the AEC.

Because the level of production is directly related to weapons requirements and reactor performance, both of which are subject to substantial change on short notice, because it is difficult to set firm specifications, because civilian requirements are so low that this capacity could not be fully utilized for peaceful purposes for many years, and because of the large investment already made in AEC plants, the establishment of duplicate fabrication facilities by industry would not be in the best interests of either the Government or industry.

NEW PRODUCTION REACTOR

C. of C. VI–3: "Enriched uranium metal and/or fabrication for the new Hanford production reactor."

MCA–8: "Enriched uranium metal and fabrication of fuel for the NPR at Hanford."

NAM–A1b: "Supply of enriched uranium * * * metal for * * * NPR at Hanford * * *."

The new Hanford production reactor, which is being built on an accelerated time schedule, wil use metallic uranium fuel elements under temperature condi-

tions similar to those which are found in current power reactors. This operating condition, representing a substantial departure from other AEC production reactors, requires that an extensive fuel element process development program be conducted to develop specifications and fabrication and testing techniques. This work is being performed concurrently with the design and construction of the reactor. To avoid delay in startup of the new reactor, the installation of the fabrication facilities must also proceed concurrently with the construction of the reactor, even though firm specifications are not available. Since even process specifications are not firm and would not be subject to change as operating experience is gained, contracting with industry for these fuel elements at this time could only result in the AEC's entering into a cost-type contract for the operation, similar to those now in effect between AEC and the contractors operating plants. Since the AEC already has in existence or will install for the development program much of the equipment required to process the uranium and fabricate the proposed type of fuel elements, the incremental AEC investment required will not be major.

However, since industry has indicated possible interest and capability for performing these operations, arrangements have been made for an industrial group to review the question of production of NPR fuel elements in private facilities. Their report has now been received but the Commission has not had an opportunity to evaluate its recommendations.

II. Reactor Design and Development

GENERAL

NAM–C1d: "Design, construction, and testing of reactors, reactor prototypes, and reactor experiments for which industrial capacity and capital exists."

Research, development, and experimentation in the general field of advanced reactor development by AEC laboratories is a prime responsibility of such installations. The Chamber of Commerce itself recognizes this role of the AEC in section VIII of its letter. The design of an advanced reactor cannot in reality be divorced from the development effort leading up to the actual prototype reactor itself.

To the maximum extent consistent with the paramount objective of obtaining the desired technical data for which it is necessary to build a prototype of a particular reactor type, it is the intention of the Commission to construct prototype plants under cooperative arrangements with utilities, public or private. It is highly desirable to have power reactor prototypes integrated into power systems to secure information on compatibility and performance and on maintenance and operation. The Commission plans to construct such facilities on its own sites only if responses to invitations are not received or are not acceptable. All power reactor prototypes constructed by the Commission, whether at a utility or Commission site, are designed and constructed under contract by private companies with the Commission generally specifying only the reactor conceptual design, approximate power size, and general objectives, plus such specific parameters as are necessary to assure obtaining the information which the reactor is intended to provide.

With respect to experimental reactors and reactor experiments, these are for the most part designed by Commission laboratories, with that portion of the design which is not a direct outgrowth of the experimental program being furnished by architect-engineers. Among the more important reasons for assigning to the laboratories, the primary responsibilty for such projects are: (1) they are generally merely an extension of a planned laboratory program and, as such, are of more benefit when designed, operated, and altered as needed to accomplish the project objective, by the laboratory personnel; (2) due to the experimental nature of the project, specifications are developed as the work proceeds and a complete set of specifications is not available for the solicitation of bids from industry; (3) in many cases, the experiments are merely modifications of previous experiments; and (4) ancillary equipment already existing at Commission sites can be used which reduces the cost of the project and the time and effort required for setting up the experiment.

Detailed comments are given below and, in general, these comments are applicable to the general design, construction, and testing of AEC reactors. Current policy is that conceptual design will be made by the best qualified organization. However, title I and title II type work is normally contracted for with engineering firms.

OAK RIDGE RESEARCH REACTOR

C. of C. II–3: "Oak Ridge National Laboratory's title 1 and title 2 design of ORR."

The Oak Ridge National Laboratory had responsibility for design of the ORR. However, titles I and II design services required for this facility were by no means accomplished exclusively by members of the ORNL engineering staff. A private organization—the McPherson Co. of Greenville, S.C.—performed a significant amount of the title II design work. The McPherson Co. participation in the design of the ORR included the design and preparation of working drawings and specifications for the complete reactor building, building services, utilities, reactor shield, reactor pool, and reactor cooling system. Oak Ridge National Laboratory, as the Commission's operating contractor, had direct responsibility for initiating and developing the overall concept for the facility, for the preparation of design criteria for all phases of the project, and for the definitive design of the reactor proper including instrumentation and controls.

The latest figures on total cost of the ORR show that less than 6 percent was expended by Oak Ridge National Laboratory engineering forces on design which could be considered as title I or title II engineering. Approximately one-third of the 6 percent was expended in preliminary work required to develop design criteria and specifications necessary for the design work to proceed. The remaining 4 percent was expended in coordination of the work with the architect-engineer and in design of the reactor proper and the reactor control system.

HIGH-FLUX ISOTOPE REACTOR

C. of C. II–1: "Oak Ridge National Laboratory's design of a high-flux isotope producing reactor."

It is anticipated that all title I and title II design of all portions of this job will be performed by an architect-engineer except for the design of the core and control systems. The control system components will be purchased from industry. Those portions of the job to be designed by an architect-engineer are a major fraction of the project.

The performance of this reactor will exceed by a large factor the performance of any existing reactor and is higher by a factor of nearly 2 than any other proposed high-flux reactor. It represents a sizable extrapolation of existing technology. In order to accomplish the research aims of the reactor, it is necessary to advance the limits of current technology. We believe it to be the purpose of our national laboratories to perform this type of development.

BEAM RESEARCH REACTOR

C. of C. II–2: "Brookhaven National Laboratory's preliminary design of the beam research reactor."

The high-flux beam reactor will be used principally for research projects that require external beams of neutrons at both thermal and epithermal energies. The conceptual design study of a new and advanced research reactor was largely an effort to develop the best compromise of the needs of the experimenters, the actual performance of a chosen fuel and moderator array as determined by critical experiments, and engineering considerations of cost, safety, and general feasibility. Even on this conceptual study Brookhaven was assisted by an industrial company, and in July 1959 statements of interest concerning all phases of the design, equipment procurement, and management of construction of the reactor were solicited from 12 industrial companies. Nine proposals were subsequently received and we are currently negotiating with one of the companies for this work.

SANDIA TEST REACTOR

C. of C. II–5: "Sandia and Los Alamos design work for the Sandia test reactor."

As of December 31, 1959, this facility was 31 percent complete and is expected to go critical in late 1960.

All design aspects of the building and practically all design aspects of the reactor and associated equipment were handled through contracts with outside

concerns. The designs of the reactor and associated equipment were based almost entirely on other components and fuel elements already in existence, and involved only minor design modifications. The total design effort for the reactor and associated equipment was covered by approximately $75,000 in outside design contracts, plus approximately 4 man-years of combined Sandia and Los Alamos time over a 3-year period. The Sandia-Los Alamos effort in this area was the minimum necessary to keep Sandia personnel sufficiently knowledgeable to insure that it would get what it needed to do its job and to provide a background for the operation of the reactor.

PROCESS HEAT REACTOR

C. of C. II–7: "Argonne National Laboratory's title I design of the process heat reactor."

The ANL made an evaluation study of those reactor concepts which are proven to see if any such concept is particularly suitable for this application. The AEC also requested the laboratory to provide a report on the conceptual design for the selected reactor concept and an outline for the research and development program for such a reactor. The title I design of the process heat reactor was not performed by Argonne but by Sargent and Lundy.

NATURAL CIRCULATION REACTOR

C. of C. II–8: "Knolls Atomic Power Laboratory's work on a natural circulation reactor for the Navy."

The development of a reactor plant for naval operation is quite different in many respects from the development of a stationary reactor plant. The compactness of the reactor system, the high-power density, the shock and vibration requirements, the maneuvering capabilities, and the operation of the plant under varying conditions of inclination gives rise to problems not encountered in a land plant. The natural circulation reactor plant is a new concept for naval application, and its successful and timely completion as well as its further advancement requires full exploitation of pertinent naval reactor technology. The Commission laboratories which have specialized in naval research and development work for about 10 years are, to our knowledge, the only organizations having the necessary technical talent, experience, and special facilities for undertaking this project in the most expeditious manner.

ARMY LOW-POWER REACTOR

C. of C. II–11: "Argonne National Laboratory's development of the Army low-power reactor."

NAM–Cle: "The first reactor in the Army low-power reactor program was fabricated by an industrial concern at its own facilities, but the second will be fabricated in a Government-owned facility."

We assume that the SM–1 plant at Fort Belvoir is the "first reactor" and the SL–1 (formerly ALPR) at the National Reactor Test-Station is the "second."

In the light of a known interest of the Department of Defense in a nuclear power plant of approximately one-tenth the capacity of the SM–1 at Fort Belvoir, six separate reactor concepts were investigated to determine which could best meet the requirements of the Department of Defense. These studies were made between January and June 1955. Of the various systems investigated, the boiling water system study by the Argonne National Laboratory appeared to be most suitable for this purpose.

Inasmuch as there was no industrial experience with power reactor systems developed at that time, Argonne was requested to undertake development and construction of the prototype 200–300 Kwe. plant which the Department of Defense requested in September 1955. In the course of constructing this plant, Argonne used subcontracts with many industrial firms. An industrial firm was awarded a contract to fabricate the fuel elements, but defaulted because it was unable to fabricate elements meeting the prescribed standards. In order that the project completion date would not be jeopardized, the fabrication of the core was undertaken by Argonne Laboratory. Since completion, the plant has been operated by Combustion Engineering.

III. Thorium

C. of C. VI–8: "Supplying AEC's needs for thorium alloy, thorium oxide, thorium carbide, * * *"

MCA–14: "Supply of thorium oxide for the homogeneous development program at ORNL."

MCA–15: "Supply of thorium metal for special projects at Los Alamos, Sandia, and Lawrence Radiation Laboratory at Livermore."

NAM–C1a: "Supply of thorium oxide for homogeneous reactor development at ORNL."

NAM–C1b: "Supply of thorium metal for special projects at Los Alamos, Sandia, Lawrence Radiation Laboratory at Livermore."

The AEC presently has no production capacity either operating or available for the processing of thorium to metal. A small pilot plant for preparation of special types of thorium oxide powders is in operation at ORNL. Several years ago a thorium metal pilot plant was built at Fernald site and operated for a short period. Since the anticipated requirements for thorium which were the basis for the Fernald pilot plant effort did not materialize, the facility was shut down in 1955 and has been dismantled. During its period of operation, the plant produced a small inventory of thorium metal and compounds from which the small needs which have developed since 1955 have been supplied. It is intended that future requirements of comparable size would continue to be supplied from this inventory as long as available. The ORNL pilot plant, on the other hand, is preparing thorium oxide powders in an effort to produce oxide having desirable slurry properties for use in the homogeneous reactor program. Oak Ridge has also procured sample quantities of oxide from industry for testing. Development work on preparation of acceptable powders supported by AEC funds has been carried out by ORNL and several private companies. The development program at ORNL is still under way. At such time as an oxide has been developed having the desired slurry properties for which a specification can be set, we would seek to obtain thorium oxide for use in homogeneous reactors from commercial sources.

Current thorium operations are limited to development efforts on the utilization of this element in AEC programs. There are some indications that there may be a continuing requirement for modest quantities of thorium metal which would exceed the current inventory. Should such develop, AEC will obtain the metal by procurement from commercial sources.

IV. Design of Facilities and Equipment

HOT CELLS AT ARGONNE NATIONAL LABORATORY

C. of C. II–4: "Argonne National Laboratory's title 1 and title 2 design of hot cells for its new research laboratory."

It is assumed that reference is made to the hot cell area in wing F of the Fuels Technology Center, now under construction. The title I and title II designs of the building were carried out completely by a private architect-engineer (Singmaster & Breyer on the basis of preliminary designs prepared by Argonne). The design of the manipulator, windows, and internal cave hardware is being carried out by Argonne because of the experimental nature of the design concept. In this particular case the cave equipment is being designed so that the operations can be carried out for extended periods of time without the need for access by personnel. The design concept represents a complete departure from present operating techniques and requires a large advancement in all aspects of remote handling equipment. This new research metallurgy facility must be gastight to contain an inert atmosphere. No existing type of master slave manipulator is designed to operate under these conditions. Although the need for this new approach to remote handling has been discussed in open forums, no commercial company is working on this problem to the best of our knowledge.

It was also felt that the design of these features should be carried out by scientists and engineers who have already used such facilities and are acquainted with other problems in the design of remote handling and viewing systems.

NUCLEAR RAMJET ENGINES

C. of C. II–6: "The Government's University of California Radiation Laboratory's design, test, and fabrication of nuclear ramjet engines."

The function of this program is to determine the feasibility of and construct a nuclear reactor as a ramjet engine and does not include design, test, and fabrication of nuclear ramjet engines on a production basis. The laboratory is subcontracting as much of this project as is feasible, considering the technical requirements and schedules involved. Subcontracts with industry currently amount to about 45 percent of the laboratory's budget for the project.

THERMIONIC CELLS

C. of C. II–9: "Los Alamos' experimental work on thermionic cells to convert fission energy directly to electricity."

This item refers to the "plasma thermocouple," a present research project at the Los Alamos Scientific Laboratory. As far as we are aware, the basic idea originated at LASL where technology in the exotic materials involved (uranium and zirconium carbide), scientific competence, and adequate laboratory facilities required are available.

This field of research is unclassified and completely open to indusry. The AEC welcomes parallel research by industry and the publication of the results of such research. LASL has published numerous documents in this area and has briefed many industrial organizations upon their work. We encourage our laboratories to undertake frontier research of this nature.

V. Depleted Uranium

C. of C. III–1: "Conversion of depleted uranium from UF_6 as required in the 'Nuclear Navy' for metal, alloys, or uranium compounds."

C. of C. III–2: "Depleted uranium metal for an AEC shielding cask project at Schenectady."

MCA–2: "Depleted uranium for all activities at the national laboratories with specific attention directed to the conversion of depleted uranium from UF_6 and the fabrication of blanket fuel elements for the zero power reactor at Argonne National Laboratory."

MCA–3: "Conversion from UF_6 of depleted uranium required for shielding cask at Bettis Field representing approximately 40 tons of cylindrical casting."

MCA–9: "Depleted uranium metal for AEC shielding cask at General Electric, Schenectady."

NAM–A2a: "Supply of blanket fuel elements for zero power reactor at Argonne National Laboratory."

NAM–A2b: "Conversion from UF_6 of depleted uranium required for shielding cask at Bettis Field."

NAM–A2c: "Supply of depleted metal for shielding cask project at Schenectady."

Depleted uranium metal is used to a very limited extent in the naval reactors program as a shielding material in certain refueling equipment where compactness is required. Specifically, it has been used in the refueling equipment for the S3G and A1W type reactor plants. The depleted uranium for this equipment was fabricated into the desired shapes at Oak Ridge. The events leading to the decision to do the work at an AEC facility can be summarized as follows: In 1957, representatives from 11 private industrial concerns were invited to a prebid conference called to determine whether commercial vendors were technically capable of fabricating the depleted uranium shielding components for the S3G refueling machine developed and being manufactured by the United Shoe Machinery Corp. Three companies responded. As a result of this conference, the decision was made to perform the fabrication work at Oak Ridge because the capability of the three interested commercial vendors was uncertain, whereas it was evident that Oak Ridge had an established capability to perform this work. All three of the interested vendors lacked experience in casting the required depleted uranium alloy, and it was questionable whether their facilities could handle the size of the castings required. Similarly, starting in 1956, the United Shoe Machinery Corp. designed and developed for the Bettis Laboratory a maintenance and refueling machine for use with the A1W type 1 and 2 reactor cores. Depleted uranium for this machine was also procured from Oak Ridge.

It is probable that the questions concerning the ZPR refer to the ZPR–VI and –IX blanket for which procurement was initiated in November 1959. (The last procurement for ZPR–III was in 1957–58.) Bids were requested for conver-

sion of UF_6 to metal and commercial suppliers have been selected for both conversion and fabrication steps.

In another case, that of the EBR–II blanket material, an exception was made to the general policy of using commercially available facilities, based on the apparent price differential that existed.

VI. Irradiation Services

C. of C. V: "Preference should be accorded private irradiation facilities in place of the current preference for loading Government facilities first. This is the best way of encouraging more private capacity. Underloaded commercial facilities exist whereas it is our impression that the Government-owned facilities are heavily loaded. AEC's practice of offering space in the Government-owned MTR and ETR should be limited to only those specific cases where private facilities are unavailable."

NAM–B: "The AEC should announce a policy to utilize privately owned reactors for materials testing to the extent that industry is able to provide space. This use of private reactors should be in preference to the use of a similar Government-owned facility. The current use of MTR and ETR for Government-sponsored research, which constitutes the great majority of the materials testing business, results in severe competition for the private test reactors."

Negotiations currently are under way to determine the extent to which irradiation services required for Commission programs can be obtained from either the Westinghouse or General Electric test reactors. As announced last summer, negotiations are also being conducted with the Babcock & Wilcox Co. for the construction of an additional test reactor. Irradiations will be continued at Commission test reactors, depending upon the type of irradiation required and the cost of outside service.

VII. Chemical Processing

COLD URANIUM SCRAP

C. of C. VI–7: "Chemical processing of cold industrial scrap."

MCA–16: "Recovery of cold fabrication scrap, both high and low enriched, from all of the above projects."

In early 1959, AEC took the initial steps to acquire more scrap recovery services from industry. In March 1959, AEC began to send bid invitations to commercial scrap recovery firms to provide this service. On November 4, 1959, AEC assigned the responsibility for developing the domestic unirradiated uranium scrap industry to New York Operations Office. That Office is acting as a central point for the AEC and its contractors for the placement and administration of contracts for commercial recovery of uranium scrap generated under the reactor development program. From March through November 1959 approximately 11 awards were made aggregating 344 kilograms of uranium with a total of $180,200 for recovery charges.

The New York Operations Office is currently establishing a system whereby the scrap available for commercial recovery will be reported by other offices, and invitations for bids will be solicited from private firms. As a result of these steps it is expected that the commercial recovery of cold scrap will grow substantially in the future.

IRRADIATED FUEL ELEMENTS

C. of C. VII: "It is recognized that the reprocessing of irradiated fuel elements represents an area that is difficult to assess commercially. However, there is no reason to believe that many chemical firms could not handle the job if pricing, regulatory, and load problems could be successfully met. While the Government is spending large sums on developing new processes which inhibit industrial investment in known processes, it can speed the transition toward a desirable commercial mode of operation by making maximum use of industrial firms in research and development and possibly the construction and operation of reprocessing plants."

NAM–A–3: "In the area of reprocessing of irradiated fuel elements, the Government can and should greatly aid in the transition to a commercial mode of operation by making maximum use of industrial groups in process research and development and in construction of, and operations related to, reprocessing plants. To promote the growth of a healthy industry in this area, Government

funds should be used to finance research and development programs in privately owned facilities in preference to Government-owned facilities."

The Commission has made a continuing effort to bring private industry into the field of chemical reprocessing of irradiated fuel elements. At the present time, a group of five electric utilities and a chemical company are studying the technical and economic feasibility of the design, construction, and operation of a privately owned facility for the processing of spent nuclear fuels. This study will take approximately 6 months, at the end of which time it is expected that industry will have a much clearer view as to the potential in this field. The study has the full support of the AEC. Other groups making similar studies would have the same AEC support.

Since there are a number of approaches to the problems of private operation in this field, and technology must be developed in order to find a satisfactory solution to the general problem, development programs must proceed consistent with the objective of obtaining economic nuclear power. AEC believes that the absence of adequate technology necessitates the continuation of its programs.

Although to our knowledge there are no facilities outside of AEC capable of undertaking major development programs on recovery of spent fuel elements, AEC is prepared to receive proposals for research and development to improve fuel recovery technology.

VIII. Instrument Development and Manufacturing

C. of C. II–10: "Oak Ridge National Laboratory's Instrument Development Section which in some instances is working on the development of instruments in competition with commercially available equipment."

C. of C. II–12: "Each of the major Government projects have developed their own, and different, hand and foot monitors, scalers, survey meters, and multichannel radiation analyzers in competition with commercially available equipment."

C. of C. VI–6: "Instrument production work at Los Alamos, Oak Ridge, and the University of California (Berkeley)."

NAM–C1g: "Personnel radiation monitors are developed and produced in instrument production sections at Government-owned laboratories. There is an instrument industry capable of furnishing such monitors and it should be used."

NAM–C1h: "Government construction of radiation measuring equipment is also in direct competition with the private instrument industry."

It is the express policy of all of the laboratories to procure instruments which are available commercially rather than to fabricate them. A survey of all laboratories and industrial establishments made in 1954 showed that over 80 percent of radiation instruments of all types were procured from private industry. A more recent survey indicates this percentage ranges from 90 percent to 100 percent depending upon the mission of the facility.

It is true that some instrument development work is continuing at major laboratories. Such work is necessary for the following reasons:

(*a*) To modify or create instruments to meet the specific requirements of a research project where the time and engineering effort necessary to prepare specifications, issue bids, instruct outside personnel, inspect for precision, and return for corrections, make outside procurement impractical.

(*b*) To develop designs in instances where commercially available instruments have proven unsatisfactory in performance and private companies have not improved their products on their own initiative but will adopt laboratory-developed designs.

While it may appear that each laboratory develops its own instruments, our survey indicates that such development is undertaken only when necessary to meet a particular condition for which a commercially available instrument is not adaptable. The facts in respect to specific instruments are:

(*a*) *Hand-and-foot monitors.*—Obtained commercially. Developed initially by the laboratories. One laboratory has recently developed an improved design for greater reliability.

(*b*) *Scalers.*—Such instruments typically must be modified to meet specific needs. The laboratories use commercial subassemblies.

(*c*) *Survey meters.*—While these meters are purchased from private industry, the laboratories have had to undertake development of more reliable designs in the absence of such development by industry.

(*d*) *Multichannel analyzers.*—To our knowledge, the only development work on these devices is that necessary to achieve devices for special applications. As

an example, one laboratory assembled one such device in calendar year 1959 at a cost of $12,000, while in the same year it procured $192,000 worth of such devices commercially.

IX. Production of Radioisotopes

COBALT 60 FOR THE HIGH INTENSITY RADIATION DEVELOPMENT LABORATORY

C. of C. VI–4: "Supply and/or fabrication of high purity cobalt for the High Intensity Radiation Development Laboratory at the Brookhaven National Laboratory."

MCA–10: "Supply and/or fabrication of high purity cobalt for the High Intensity Radiation Development Laboratory at the Brookhaven National Laboratory."

NAM–C1c: "Supply of high purity cobalt for High Intensity Radiation Development Laboratory, Brookhaven."

The high purity cobalt in the form of nickel-plated targets for the Brookhaven radiation development facility was furnished commercially. All such cobalt is and has been supplied by commercial vendors to AEC. The canning of the cobalt for use in a reactor is controlled by the reactor operator to insure the safety and integrity of all material inserted into the reactor. Approximately 500,000 curies of cobalt 60 are needed for the Brookhaven National Laboratory program and are being produced in the engineering test reactor. At the time the radiation was begun, no commercial sources of cobalt 60 existed.

PRODUCTION OF CERTAIN RADIOISOTOPES

C. of C. IV: "The Government is currently producing certain radioactive isotopes in a commercial way (e.g., cobalt 60, iodine 131, carbon 14, sulfur 35, phosphorus 32). The demand for these radioactive isotopes is now at a level which makes commercial production feasible and commercial facilities exist which should be utilized."

C. of C. VI–8: "Supplying AEC's needs for * * * high purity cobalt and radioisotopes."

AEC's needs for radioisotopes are small in relation to AEC sales to others, representing 14 percent of the dollar sales. Until such time as commercial producers can supply the requirements, AEC production of radioisotopes will be necessary to meet all or part of its own needs. Commercial production of radioisotopes is small at the present time except for cobalt 60.

The Government is producing some, but not all, radioisotopes in a commercial way. In 1955, AEC discontinued the production of cyclotron-produced radioisotopes because commercial sources were in a position to produce and market these products at reasonable prices. Also, many of the radioisotopes currently distributed by AEC are produced on a laboratory or semiworks scale because of the small demand, principally for research and developmental uses.

The AEC has never competed with the pharmaceutical industry in the manufacture and distribution of pharmaceuticals containing radioisotopes. The AEC has also turned over to private industry the following related services:

(a) Synthesis and marketing of C–14-labeled organics.
(b) Cobalt 60 encapsulation services.
(c) Cobalt 60 gamma irradiation services.

The foregoing demonstrates the way AEC policy has been carried out when private industry is ready to produce or perform services at reasonable prices.

The statement is made that the demand for certain radio-isotopes is now at a level which makes commercial production feasible. The five leading revenue producers are:

	Fiscal year 1959 sales [1] *(in thousands)*
Cobalt 60	$659
Iodine 131	325
Phosphorus 32	171
Polonium 210	208
Carbon 14	263
Total	1,626

[1] Includes research discounts of about $207,000 granted to users under the AEC radioisotopes research support program.

These five radioisotopes represented 65 percent of AEC's dollar sales. All except cobalt 60 require radiochemical processing with attendant high investment in plant facilities. Indications until recently have been that the volume of sales is not sufficient to attract private capital. In fact, the Commission has cooperated with a number of private companies who have made very detailed examinations of AEC isotope production activities and the commercial opportunities for undertaking the total isotope program. These private groups did not find the market to be sufficiently attractive for a commercial venture involving the total program. It has only been within the last few months that the Commission has received concrete evidence of private interest and intention to produce isotopes. We understand that two existing commercial test reactors are irradiating cobalt, and that one commercial company is considering production and distribution of iodine 131 to be produced in another company's irradiation facilities. Power reactor operators have thus far indicated no interest in producing radioisotopes.

The nature and extent of private interest in the production of cobalt 60 is being explored. Industry plans will be taken into consideration in determining the Commission's future plans to meet requirements, particularly for megacurie sources. One of the objectives of AEC is to develop large-scale uses for radioisotopes. Success in this objective is dependent on solving technical problems, achieving large-scale availability, and lowering prices. When this objective is reached, the demand for radioisotopes should be at a high-enough level to attract private capital and make commercial production of a wider variety of radioisotopes economically feasible.

X. Miscellaneous Services

FILM BADGE PROCESSING

C. of C. VI–5: "Servicing of film badges by AEC contractors."

NAM–C1f: "Furnishing of film badge service for personnel monitoring. Although a number of industrial firms offer this service, competing services are performed at Oak Ridge, Brookhaven, Savannah River, Sandia, etc."

Servicing of film badges at most AEC installations is regarded as an integral part of the operating procedures established to protect the health and safety of employees. The processing and reading of film badges is intimately related to interpretation and other steps in a monitoring system. Wherever radiation exposure could reach dangerous levels or where personnel must work in radiation zones, quick detection and rapid estimation of exposure are needed for both personnel protection and control of operations; any time delay involved in relying on a commercial contractor to provide these services is unacceptable.

One AEC contractor engaged in the processing of unirradiated source materials is understood to be considering the use of commercial film badge servicing. Another, responsible for operation of an AEC laboratory, is giving serious consideration to canceling its commercial contract in favor of a return to doing its own film badge work because of several years of unsatisfactory experience with inaccuracies and errors on the part of two commercial contractors.

PRINTING

C. of C. VI–9: "Printing facilities at Government facilities."

Except for the printing establishment maintained for the production and dissemination of scientific and technical reports by the Technical Information Services Extension at Oak Ridge, AEC printing facilities are an integral part of the administrative support for routine management and operation at each AEC installation. Day-to-day operational needs are characterized by large numbers of short production runs with short leadtime.

Provision of printing equipment for an AEC installation requires prior authorization by the congressional Joint Committee on Printing, which periodically reviews production reports to assure that equipment continues to be needed. Typically, AEC installations procure from commercial sources a large volume of unclassified printing when large production runs are involved and leadtime permits.

TRANSPORTATION

C. of C. VI–10: "Operation and maintenance of automotive equipment and transportation facilities (bus and rail) at Government installations."

In the provision of automobile service at AEC installations, our contractors operate fleets of Government-owned vehicles of varied types. Where available,

vehicles are obtained from Government motor pools. Peakloads are also met by renting equipment. Automobile service at most AEC installations is an integral supporting activity which can be provided most efficiently by the operating contractor rather than an outside commercial source.

At AEC installations which are in relatively isolated or rural locations, servicing and maintenance of motor vehicles are generally performed in AEC repair shops. There are, however, many locations where reliance on commercial shops and facilities is the practice because it has been found to be practical and more economical.

Bus transportation is provided by our operating contractors at some major AEC installations. Because of the isolation of these facilities, experience demonstrates that commercial bus service cannot be provided on a paying basis, and operating conditions make it impractical to contract for such services at a reasonable cost.

Intraplant railroad service is performed at several installations by AEC operating contractor. At Oak Ridge prior to 1956, the plant railroad was operated under contract by one of the major railroad companies. Cost studies prompted the AEC to transfer responsibility for maintenance and operation of the plant railroad to its operating contractor. Since 1956 the estimated cost has been less than one-third of the minimum amount payable under the earlier contract with the railroad company.

In general, intermittent low-volume operations within our plant sites, often involving special equipment and handling, are best performed as a part of the integrated responsibility of the plant operating contractor.

POWER DISTRIBUTION

C. of C. VI–11: "Power distribution in connection with Government installations."

Electric power distribution systems at AEC installations are operated in accordance with the normal industrial practice under which the consumer owns and operates the distribution system beyond the point of delivery, usually the high side of the initial stepdown transformer.

Generally, responsibility for the distribution of electric power within an AEC installation is such an integral part of the overall responsibility of the operating contractor for carrying out the principal mission of the installation that a separate contract for power distribution services could not be tolerated.

A special situation exists at Los Alamos, where many private residences are served from the distribution system. The feasibility of eventually disposing of that part of the distribution system which serves the town facilities is now being studied.

COMMUNICATION

C. of C. VI–12: "Communications systems at Government installations."

Telephone, teletype, and radio communication equipment is regularly used by AEC installations. Only recently has it become possible to obtain radio equipment on a lease-maintenance basis from commercial sources, and substantial quantities of radio equipment are being secured under such arrangements.

Essentially all teletype facilities used by the AEC are leased from public utilities such as American Telephone & Telegraph Co., Western Union Co., and Radio Corp. of America. Teletype traffic of AEC is processed over networks and tielines provided by public utilities as well as over the military and other Government networks.

Nearly all AEC telephone service is provided by public utilities, such as the American Telephone & Telegraph Co., Bell Telephone companies, and independent telephone companies.

The notable exception is at Hanford, where during World War II a Government-owned telephone system was built because the local telephone company could not undertake to serve so large a site. Major portions of the Hanford system, serving the business and residential areas, were sold to a public utility. Those portions directly and exclusively serving the Hanford plant areas are still owned by AEC and operated by the AEC prime contractor.

Previous analyses have indicated that the present arrangement is more economical than would be the purchase of the service from a telephone company under the rates established for that geographical area. Further studies will be made.

MACHINE SHOP FACILITIES

C. of C. VI–13: "Machine shop facilities at the Argonne National Laboratory."

Machine shop jobs are performed in the Argonne National Laboratory's own central shops when (1) there is urgency to complete the job, (2) private companies are not able to perform the work, and (3) shop fabrication must be carried out coincident with design, development, and proof testing of the apparatus being built. When these factors are not present, it is the policy of the laboratory to order the work from private enterprise.

Over recent years steps have been taken to develop commercial sources for metal fabrication having the qualifications and experience to perform the type of work generated by the laboratory. A large number of qualified companies is now available.

Chairman ANDERSON. Now do we understand that Admiral Rickover is going to make some comments?

Mr. FLOBERG. That is my understanding, that you scheduled him for this time, Senator.

Chairman ANDERSON. Very well, admiral.

Mr. FLOBERG. I understand, Senator, that you scheduled Colonel Williams to follow Admiral Rickover.

Chairman ANDERSON. Yes.

While you are supposed to talk about the industrial aspects of the naval program, as I indicated to you a moment ago, you are just shortly back from a trip to Britain and we would be very happy to have any comments you care to make that might be of advantage to the committee or to those people who might be reading this record.

STATEMENT OF VICE ADM. H. G. RICKOVER, ASSISTANT DIRECTOR FOR NAVAL REACTORS, DIVISION OF REACTOR DEVELOPMENT, ATOMIC ENERGY COMMISSION

Admiral RICKOVER. Thank you, sir.

Chairman ANDERSON. We are always glad to have you with us.

Admiral RICKOVER. I am always glad to be here, sir.

Do you wish me to talk about the naval program first, and the British program next?

Chairman ANDERSON. This is wide open. You take your own choice.

Admiral RICKOVER. I understood you wanted to get an idea how far we have gone toward using industry in the naval program; I have some figures.

The total investment by the Government for research and development, construction of laboratories and prototypes, operating costs and including the nuclear-propulsion plants for the first two nuclear submarines, the *Nautilus* and the *Sea Wolf*, through June 30, 1960, will be about $950 million. This sum covers the entire program, every dollar that has been spent by the Government for the whole naval program.

Chairman ANDERSON. Just about the same amount that was spent for the aircraft nuclear propulsion program.

Admiral RICKOVER. Yes, sir.

Chairman ANDERSON. The results are a little different.

Admiral RICKOVER. They have a much harder problem, sir.

Chairman ANDERSON. I know.

Admiral RICKOVER. The Navy, at present, has 37 nuclear-powered submarines and 3 nuclear surface vessels authorized. We currently

have in commission nine nuclear-powered submarines and we will have nine more by the end of calendar year 1960. We will have a nuclear-powered cruiser by that time, also by the end of this year we will have 18 nuclear-powered submarines in commission. The total amount which has been appropriated for these ships—but not all spent—is about $3½ billion.

So the $950 million of development costs has already resulted in an investment of $3½ billion for ships.

I will repeat the figure, sir.

The total sum of money authorized by the Congress for the nuclear Navy to date is about $3½ billion; this provides for 37 nuclear-powered submarines, an aircraft carrier, a cruiser, and a destroyer.

We have contracted with industry for about $200 million for nuclear cores, an additional $350 million for nuclear plant components, and about $65 million for zirconium and hafnium.

We expect within the next 5 years to order an additional $140 to $150 million worth of new nuclear cores, and about the same amount for replacement cores.

All of this money is being spent under competitive lump-sum contracts with private industrial organizations, and the facilities for manufacturing these items are entirely paid for by industry. The Government has not spent one dollar for these facilities. In fact, we have even denied the companies certificates of necessity for fast tax writeoffs.

So, contrary to the situation that obtains in the aviation industry and in the missile industry, there is no Government investment here. We have adopted the capitalistic system, Senator Anderson.

Chairman ANDERSON. May I ask you one question?

You mentioned the amount of money you spend for the cores, the amount of money you plan to spend, some $140 or $150 million for additional cores and replacement cores.

Admiral RICKOVER. There will be about $140 million for replacement cores, in addition there is also about $140 to $150 million worth of new cores.

Chairman ANDERSON. We are talking about the difficulties of getting this atomic energy industry under way around the world.

Has the cost of cores gone up or is there some saving?

Admiral RICKOVER. The cost of cores has decreased about 40 percent in the last 2 years.

Furthermore, the life we are getting out of the cores has gone up about 70 percent.

Roughly, the effective reduction in cost is about three times. The cost has gone down to about one-third if you figure it on a kilowatt-hour or unit of energy output.

Chairman ANDERSON. That is what I wanted to get to.

The Navy has been a great developer of atomic power, particularly in submarines. You have seen the cost of atomic power in the submarines going down by the longer life of the core and the lower cost of the core.

Admiral RICKOVER. Yes, sir.

For example, in the *Skipjack*-type submarine, the core cost has gone down to about 40 percent of its original cost. The life of the new core we will install will be about 30 percent greater than the first one.

Chairman ANDERSON. I think that is of some interest to industry because they have many, many plants across the country. It may be that industrial costs will go down in the same pattern as your costs go down.

Admiral RICKOVER. Our costs have gone down.

Obviously when industry invests about $100 million in manufacturing facilities, they must, in a relatively short period of time, amortize their costs. I understand most of the companies making items for us are now in the black, in that they are beginning to make profit. I don't believe any of them have fully recovered the entire cost of their investment, but they are no longer losing money.

This is natural with any new industry.

We have always aimed to have at least three sources of supply for everything we buy. This is advisable in order to get true competition. It is also good from a national standpoint in that we won't be held up in case of an emergency, or if we desire to expand the number of ships we build—as the Navy is currently recommending. We now have facilities to take care of such an expansion.

I am confident if Congress accedes to Admiral Burke's request and gives the Navy six or more additional *Polaris* submarines this year, there will be no strain on the naval nuclear industry. We are ready to take care of such an expansion.

It has been a difficult job to train industry to do this new work because it is far more complicated than any previous work they have been used to.

We have done another thing. Instead of doing all this procurement through a Washington agency, we have set up outside agencies to do it. This keeps the number of people in Washington at a minimum and should make rents cheaper here, Senator.

Chairman ANDERSON. Probably get a lot more work done.

Admiral RICKOVER. Yes, sir.

Chairman ANDERSON. Go ahead.

Admiral RICKOVER. That is about all on industrial participation.

Chairman ANDERSON. We have a nice attendance now and we will be glad to hear about the things you found out abroad.

Admiral RICKOVER. I discussed two items with the British. One, the progress that they are making on their own nuclear submarine.

The Vickers Shipbuilding Co. is building the submarine under a contract from the Admiralty. Rolls-Royce is responsible for the reactor plant.

As you know, last year your committee approved the furnishing of information and equipment to the British for this first plant. It is going ahead on schedule. I cannot in open session say what the schedule is.

The British are also building a prototype submarine reactor plant at Dounreay, on the north coast of Scotland, in order to train their people.

The British intend to build a second *Skipjack*-type submarine next year; we have helped them set up manufacturing facilities they will not be dependent upon the United States for the second submarine. They will be able to make all reactor plan items themselves. This will be good for them and good for us, because it will reduce the extent of interference with our own program.

To summarize: They have one nuclear submarine under construction and they are asking for another.

With regard to other types of reactors, the United Kingdom Atomic Energy Authority reactor development program continues to place main emphasis on the gas-cooled approach. Their work on the advanced gas-cooled reactor, known as the AGR, and on a high-temperature gas-cooled reactor, known as the HTGR, represents their latest thinking in this field.

In addition, they are continuing to work on the fast-breeder reactor program with expectation of completing the design of a $2,000- to 300,000-megawatt electrical prototype in early 1963, and receiving authority to build such a reactor prototype plant that same year.

A small design effort is also under way on a steam-cooled heavy-water moderated reactor to determine the potential of such a reactor concept.

So they are concentrating almost entirely on the gas-cooled reactor. They are doing practically no additional design work on the Calder Hall type reactor. Nearly all work is on the advanced gas-cooled reactor and on the HTGR, which is a joint effort among themselves and a number of European countries. The HTGR is similar to the reactor General Atomics is working on.

The British stated that the advanced gas-cooled reactor, which has a 28.5 thousand kilowatts electrical output, being erected at Windscale, is on schedule. They expect to complete plant construction in April 1961, and the reactor to reach a significant power level near the end of that year.

Chairman ANDERSON. Mr. McCone, that is about the same size at Oak Ridge, is it not, and the same type?

Mr. MCCONE. Just about the same.

Admiral RICKOVER. There is close collaboration between Oak Ridge and the British. They are giving complete information on the reactor to us. There is no difficulty such as we experienced previously with the Calder Hall reactor. Everything is being given, sir.

The high temperature gas-cooled reactor, the HTGR, which is 10 megawatts thermal, or about 2½ megawatts electrical—is an experimental type.

Chairman ANDERSON. It is very, very much smaller than General Dynamics?

Admiral RICKOVER. Yes, sir, it is smaller.

Chairman ANDERSON. The same type?

Admiral RICKOVER. Yes sir, the same type.

Chairman ANDERSON. It is about a fifteenth in size?

Admiral RICKOVER. It is 10 megawatts thermal; you must divide that figure by about four to get the electrical output.

Representative HOLIFIELD. Metal clad fuel rod?

Admiral RICKOVER. No. This is a different type. They have a fuel element consisting of graphite disks impregnated with uranium. The fuel element is still in the development stage and some changes have recently been made.

There is complete exchange between the British and us, through General Atomics, on this reactor also. In fact, one of the British scientists who had a great deal to do with the inception of this reactor is currently working at General Atomics.

Representative HOLIFIELD. Mr. Fortescue.

Admiral RICKOVER. This project was approved about a year ago as a cooperative project of the nuclear energy agency of the Organization for European Economic Cooperation, the OEEC. The published current cost estimates for the project indicate a total cost of $38 million.

Chairman ANDERSON. $38 million?

Admiral RICKOVER. $38 million.

Chairman ANDERSON. That is within $3 million of what General Dynamics, as I recall, put into the other one here, and we are going to get 35,000 kilowatts heat.

Representative HOLIFIELD. It sounds like a very high cost for such a small reactor.

Admiral RICKOVER. It is probably a realistic cost, not a high cost, sir.

Chairman ANDERSON. You have been reading figures on other reactors.

Admiral RICKOVER. I believe this is the proper time to tell you about cost estimating for Government projects in the 15th century, Mr. Holifield.

Representative HOLIFIELD. You are not acquainted with how cheap you can build reactors. You have heard about the big reactor at Dresden that only cost $50 million.

Admiral RICKOVER. You mean the published figure?

Representative HOLIFIELD. Published.

Admiral RICKOVER. Yes, sir.

Representative HOLIFIELD. That is where I got my information.

Admiral RICKOVER. I would like to tell you about Pope Pius II's experience with cost estimating in the 15th century. I believe it will be enlightening to this committee. What I will say is taken from "Memoirs of a Renaissance Pope—The Commentaries of Pius II."

Representative HOLIFIELD. I think it might be very pertinent. It is at least up to date.

Admiral RICKOVER. The Pope had received many insinuations against the architect—that he had cheated; that he had blundered in the construction of a church and a palace; that he had spent more than 50,000 ducats when his estimate had been 18,000. The law of the Ephesians, according to Vitruvius, would have obliged the architect to make up the difference. He was a Florentine named "Bernardo," hateful to the Sienese from his mere nationality. In his absence everyone abused him. Pius, when he had inspected the work and examined everything, sent for the man. When he arrived after a few days in some apprehension, since he knew that many charges had been brought against him, Pius said, "You did well, Bernardo, in lying to us about the expense involved in the work. If you had told the truth, you could never have induced us to spend so much money and neither this splendid palace nor this church, the finest in all Italy, would now be standing. Your deceit has built these glorious structures which are praised by all except the few who are consumed with envy. We thank you and think you deserve especial honor among all the architects of our time"—and he ordered full pay to be given him and in addition a present of 100 ducats and a scarlet robe. He bestowed on his son the grace he asked and charged him with new commissions. Bernardo, when he heard the Pope's words, burst in to tears of joy.

Which he should have.

Chairman ANDERSON. I think without objection we will send a copy of that to Consolidated Edison.

Admiral RICKOVER. What I have said is really more appropriate to read to the Appropriations Committee, but I think you are faced with this problem, too.

Chairman ANDERSON. Now we have the Pope fixed, where do we go from here?

Admiral RICKOVER. Is this enough on the British program?

Chairman ANDERSON. Yes.

Admiral RICKOVER. The only other thing is the PWR. I await questions from the committee, sir.

Chairman ANDERSON. We are going into that in the authorization hearings, Admiral Rickover. I asked the Chairman the other day about the contract with Duquesne. He gave us a good answer as to how far we had gone thus far. All I can say to you is that many of us on the committee strongly support the fact that the PWR at Shippingport has contributed greatly to the art and science. It has been a little more costly than we anticipated for which we give you tears of joy.

Admiral RICKOVER. May I leave, sir?

Chairman ANDERSON. Yes.

Admiral RICKOVER. I leave "with tears of joy," sir.

Chairman ANDERSON. Colonel Williams.

STATEMENT OF COL. DONALD G. WILLIAMS, ASSISTANT DIRECTOR FOR ARMY REACTORS, DIVISION OF REACTOR DEVELOPMENT

Colonel WILLIAMS. Thank you, sir.

Chairman ANDERSON. There was a question raised the other day on the Army package power reactor. You are going to comment on that?

Colonel WILLIAMS. Yes, sir.

Chairman ANDERSON. I think Mr. Price asked the question.

Representative PRICE. Yes.

Chairman ANDERSON. Mr. Price, if he does not answer your question specifically, you ask it again when he gets through.

Colonel WILLLIAMS. All right, sir. I will speak from informal notes.

The Army nuclear power program is the joint AEC–DOD program in which the Army represents the Department of Defense as the cognizant agency. The primary mission of our program is to develop a family of what we might call ground-based nuclear powerplants in the power range from around 100 kilowatts up to as high as 40,000 kilowatts electrical, for all three military services. We have on our staff, strictly a joint staff, the Air Force, and Navy people in addition to people furnished by the Corps of Engineers, the primary DOD agent, also, representatives of the other technical services of the Army.

We feel that in developing these small plants we are also developing an industry that has some firm convictions on the long-range significance of plants in this small size, not only for military use but also for civilian use in remote areas.

When we receive a requirement for the development of a new type of plant from the Department of Defense, we normally contract with

the best qualified firm for the design, development, construction, and operation of the prototype. In this way we are looking at a single contractor all the way through the project, and we avoid splits in responsibility. Such contractors are evaluated against several specific criteria, such as these.

Previous experience in similar-type work, the qualifications and availability of personnel for this work, the facilities owned and operated by the contractor which could be made available to our programs, the interest and willingness of management to devote the necessary time and effort to our project, and their long-range interest and intent to manufacture the plant as a production line item subsequent to its development.

When the prototype plant has been developed, we shall prepare procurement, performance-type specifications which then will be the basis for the procurement of subsequent field plants on a competitive, fixed-price, guaranteed-performance basis from industry as a whole.

In the case of the stationary or barge-mounted plants at the larger end of the family we are working on—in the 10,000-, 20,000- 40,000-kilowatt range—we consider that the nuclear industry has developed the necessary technology for these types of plants in other reactor programs. Accordingly, when we get a project for a plant of this size we will not count on much in the way of development. We will go straight to industry for fixed-price, guaranteed-performance, competitive-type bids.

Mr. RAMEY. We are due for a report on this type of plant as well as the smaller ones in relation to our authorization for remote size plants.

Colonel WILLIAMS. Yes.

Mr. RAMEY. That is due April 1.

Colonel WILLIAMS. That is correct.

Mr. RAMEY. You mentioned that after you have developed a plant and run it a little bit, then you run up specifications for further production and manufacture of plants for the military. Have you reached that stage yet?

Colonel WILLIAMS. No, sir; we have not. It is our intention to do this. I will mention this as I hit the high spots of some of the contracts we have.

Mr. RAMEY. From an industrial point of view, it would seem very desirable if industry could be on notice what kind of market they could expect for the plants over the next few years. Perhaps you need a 10-year Army reactor program, something that would give your industry something to shoot at and something to expect especially during these lean years.

Representative PRICE. At least 10. Give us a lot of time.

Colonel WILLIAMS. This would be helpful to industry and would also be helpful to us.

Representative HOLIFIELD. The way the things are going, there may not be any Army 10 years from now. I would not ask you to agree to that.

By the way, what size reactors are you talking about in megawatts?

Colonel WILLIAMS. From 300 kilowatts, our smallest one, a boiling water job at the National Reactor Test Station in Idaho. This is the stationary low-power, SL–1 plant. It has been in operation a

little over a year. That is the small end. Next we have the Fort Belvoir job, the SM–1, that is up around 2,000 kilowatts electrical, pressurized water, formerly the APPR.

Representative PRICE. We have had that Fort Belvoir job for quite a few years. What progress has been made since the Fort Belvoir job?

Colonel WILLIAMS. We are improving components, essentially all the components in the plant, such as improving the instrumentation by transistorizing, improving our steam generator materials, cutting down our corrosion problems, and improving the fuel elements to get longer life and higher power. One of the biggest things we are doing is rearranging this stationary plant into a set of boxes, each box being transportable by air, rail, trailer, or ship. Our contractor, Alco Products, Inc., who built the Fort Belvoir plant, has come up with a design of putting this Belvoir plant into a set of some 27 air transportable boxes. To give you an idea, sir, of what this means, the Belvoir plant as built in its fixed stationary building, with concrete vapor containment and so on, would require the airlifting of something lke 2,500 tons of equipment and materials, not including the aggregate that goes into the concrete. Such a stationary plant requires anywhere from 18 months to perhaps 2 years to build, and surely two or more construction seasons in the Arctic where construction seasons are short.

The rearranged Fort Belvoir design, in 27 boxes, will have a total weight of about 300 tons to be shipped, versus about 2,500 tons for the Belvoir plant. The onsite time to assemble and get this plant operating will be about 3 months instead of 18 months or 2 years. This we think is a big step for several reasons:

Among other things, this helps us cut down on the very high unit construction cost in Arctic regions where labor and everything else are extremely high, perhaps two, three, or four times the cost in the United States.

Representative HOSMER. Is that similar to the thing that Martin wanted to work on?

Colonel WILLIAMS. This is correct, sir. Martin has a contract with us to develop and build a completely prepackaged plant, optimized considerably over the first one, coming in a year later. The first plant that I mentioned is to be in operation next September. The one that Martin is building will go into operation at Sundance, Wyo., about a year later.

Representative HOSMER. Why are you doing both the packaging of the Belvoir job and the Martin job?

Colonel WILLIAMS. The packaging of the Fort Belvoir-type plant was to meet an early Army operational requirement for the Polar Research and Development Center, a camp that is being built in the ice cap. The Army is procuring this nuclear plant, the PM–24, to provide the heat and electricity for the base load there. The operational date for this plant is September 1960. The other one, the Sundance plant, the PM–1, is going into a new Air Force Aircraft Control and Warning Station for which there is not the same operational urgency; we have a year longer, until September 1961, to get that plant operating.

Representative DURHAM. How many at the present time are being built under the supervision of this program?

Colonel WILLIAMS. At the present time, sir—may I run through them, those operating and those in various stages of being built. First we have the Fort Belvoir one, then the earlier prepackaged one that is now under procurement by the Army; then the later prepackaged one that comes in from Martin under AEC contract. On the Army side we are also building the Alaska plant, the so-called SM–1A, which is a takeoff of the Fort Belvoir design. It is a stationary plant that is being built at Fort Greeley, Alaska, an Army post near Fairbanks. This accounts for the pressurized water types which are built or being built, with one other plant in the 6,000 ICW range under development.

In the boiling water category we have operating the SL–1, the 300-kilowatt plant at Idaho. We also have under investigation and study portable verions of this plant in the 300-kilowatt and 1,000-kilowatt sizes.

Representative DURHAM. Two of those are for the Army; is that correct?

Colonel WILLIAMS. Yes, sir. The two field plants, SM–1A and PM–2A, are being funded solely by the Army.

Representative DURHAM. And the other two are for whom?

Colonel WILLIAMS. The SL–1 and PM–1 are being developed in the overall program, sir.

Representative DURHAM. The Army has them all?

Colonel WILLIAMS. The Army is the only service building field plants at this time. The other plants in our programs are developmental plants. Although our program is called the Army nuclear power program, our mission is for all three services, and we use the people and the dollars from any source from which we can get them.

Representative DURHAM. We have construction requirements before us now for 1961. Is there any in the request for 1961?

Colonel WILLIAMS. No, sir. The only military field plants that are firm as of today are the stationary plant at Fort Greeley and the first prepackage plant to go into the ice cap, both of which the Army is building.

Representative DURHAM. They have all been authorized?

Colonel WILLIAMS. The Greeley plant was authorized in fiscal year 1957; the ice cap plant is being procured with equipment and research and development funds from fiscal year 1959 and fiscal year 1960.

Representative DURHAM. You are building those out of Army funds; is that correct?

Colonel WILLIAMS. That is correct, sir.

Representative DURHAM. Primarily.

Colonel WILLIAMS. Strictly with Army funds.

Representative DURHAM. What happened to the Navy's request?

Colonel WILLIAMS. Is this for Guam, sir?

Representative DURHAM. Yes.

Colonel WILLIAMS. The DOD proposed some months ago that the Atomic Energy Commission and the Navy collaborate on building a 20,000-kilowatt plant for Guam. The Atomic Energy Commission received this as essentially a good idea. However, in the final analysis, the funds from the Navy were not forthcoming. Therefore, it

did not make particularly sound sense for the AEC to press for their share of that plant. The project was withdrawn.

Representative DURHAM. The construction authorization will be completed in a few days for 1961. Did the Army, Navy, or Air Force request any plants this year in the 1961 budget?

Colonel WILLIAMS. No, sir.

Representative DURHAM. They did not?

Colonel WILLIAMS. They did not.

Representative DURHAM. There was none requested?

Colonel WILLIAMS. That is right.

Representative DURHAM. That is all, Mr. Chairman.

Chairman ANDERSON. You said on Guam that the funds were not forthcoming?

Colonel WILLIAMS. Yes, sir.

Chairman ANDERSON. You mean to say, do you not, that the Navy had its choice of putting all the money or not putting up any, and the Navy elected to take the easier route of not putting up the money?

Colonel WILLIAMS. Sir, what the Navy's philosophy was I don't know. All I know is that they did not put up the part we hoped they would put up.

Chairman ANDERSON. It was cheaper to build a conventional plant than to build the atomic plant.

Colonel WILLIAMS. That is right.

Chairman ANDERSON. And the Navy wanted to stretch its budget somewhere else. By that same yardstick, it is cheaper for the Army to build a regular plant in a great many of these places. It would be cheaper for Dresden to build a conventional plant. It would be cheaper for Consolidated Edison to build a conventional plant rather than a nuclear plant. Then there would be absolutely no progress of any kind. Wouldn't that be true?

Colonel WILLIAMS. Yes, sir.

Chairman ANDERSON. Would it not be desirable to find out if it would not save some money at Guam to put this plant in? The testimony was that once the plant was built there might be very substantial saving. The answer was, that would cut down on the fuel that would have to be delivered out there to the Navy at Guam.

Colonel WILLIAMS. For a military plant, sir, there are areas where nuclear power is competitive. Guam is one of those which appears economical in the long run. However, the problem is what has to be funded in a particular fiscal year for the initial capital costs. These are much higher than for conventional plants, of course.

Representative DURHAM. I was very hopeful that this would be one program we would stick with and try to do something about for the future, not only for the Army, Navy, and Air Force, but for the benefit of our industrial development in this country.

Colonel WILLIAMS. Yes, sir.

Representative DURHAM. It seems to me that you are doing very much like Euratom is doing. They did not come in and ask for any request this year, Mr. McCone.

Mr. MCCONE. No. The only project that has been under discussion, and the colonel has reported on it accurately, is the Guam project.

Representative DURHAM. I know that was discussed before the committee last year when we were authorizing these. I have not

looked completely through the Navy's request this year for authorization because we have not completed it.

Colonel WILLIAMS. We are trying to get the military services to specify their plans for the next few years—5 years or 10 years. They are uniformly in favor of what we are doing. They very much want the plants that we are developing, but for fiscal 1960 or fiscal 1961, the funds were not forthcoming.

Chairman ANDERSON. You cannot expect the funds to be forthcoming unless somebody strikes the rock with a rod. That is what they did in the Bible. You certainly have to ask for it. The appropriation committees of the Senate and House just do not shower down funds on you.

Representative HOLIFIELD. You remember all the trouble Moses got into for hitting that rock. He did not get to go to the Promised Land.

Chairman ANDERSON. There was another program at Antarctica where several people believed that an atomic power plant might be of some use down there. Senator Jackson is not here at the moment, but he strongly believed that.

Colonel WILLIAMS. Yes, sir.

Chairman ANDERSON. Do you think he has a chance to live long enough to see the Army ask for it?

Colonel WILLIAMS. I hope for it, just as much as anybody.

Chairman ANDERSON. I know, but hope——

Colonel WILLIAMS. I beat on the rock, but it takes someone with a larger club.

Representative HOLIFIELD. "Hope long deferred maketh the soul sick."

Chairman ANDERSON. That is what I was hunting for. I just hope sometime that you will see fit to send us over a letter telling us if there is any hope for Guam at any time.

Representative PRICE. I might say on this point, this is more or less up to what the Navy desired. I think the Commission is in a position that they have to wait to see whether the Navy makes a requirement out of that project over there. So far the Navy has not done so.

Chairman ANDERSON. By the same token the Navy would never have made the requirement for a nuclear-propelled submarine.

Representative PRICE. That is correct.

Chairman ANDERSON. It cost too much.

Representative PRICE. That is correct. They could see some justification for it a year and a half ago. Recently they can't. Maybe conditions have changed over there, the oil supply and so forth. At the present time I think the problem will have to be resolved through an inquiry to the Department of the Navy.

Colonel WILLIAMS. Sir, as to our effect on industry, may I say a little more about how the Army has contracted for producing their field plants. The Alaska plant was contracted for on a business-as-usual, fixed-price basis by the Corps of Engineers. We in the Army nuclear power program are available for technical backup. The Alaska District Engineer is the contracting officer. The prime contractor for this project is the Peter Kiewit construction firm, which has considerable arctic experience. Their nuclear subcontractor is Alco Products,

the plant designer. It is a conventional pattern we are following in producing these field plants. We feel that this is a step in the right direction.

Similarly, the plant for the ice cap installation, the contracting office here is the Eastern Ocean District of the Corps of Engineers, and the prime contractor again is Alco Products. We in the Army nuclear power program stand by for technical advice, review of drawings, and so on, to be sure that they don't go off the deep end.

Representative DURHAM. I thoroughly understand your position. Of course, somebody has to come to you and request that a certain job should be done. I was not criticizing you or the Commission at all.

I must say that you are working for an emergency in the future. You have to be ready when it comes. You cannot do it without know-how.

Colonel WILLIAMS. Yes, sir. I think the difference between our program and the Navy program is that in the case of the submarine, nuclear power gives them an operational capability which can be met in no other way. In the Army nuclear power program, on the other hand, what we are really doing is developing nuclear substitutes for diesel plants. Although it is desirable to reduce the logistics problem of hauling many thousands of barrels of fuel oil across the sea, nevertheless there are ways of getting it there; and thus we do not offer the unique operational capability aspect which the submarine has, for example. I am sure this is a significant consideration in the philosophy of the three services with regard to the plants being developed in the Army nuclear power program.

Chairman ANDERSON. Let me say, colonel, if we appear to be asking you a lot of questions that should not be properly addressed to you, it is only because many people here have been anxious to see this developed for a long time. You understand we are not trying to hop on you.

Colonel WILLIAMS. I will keep beating on the rock, anyway.

Chairman ANDERSON. If there are no other questions, thank you very much.

Colonel WILLIAMS. Thank you.

Mr. FLOBERG. Senator, would you like to move back into this Biblical and theological atmosphere; I can discuss isotope development.

Chairman ANDERSON. Please go right ahead.

STATEMENT OF JOHN F. FLOBERG, COMMISSIONER, AND HAROLD L. PRICE, DIRECTOR, DIVISION OF LICENSING AND REGULATION, ATOMIC ENERGY COMMISSION—Resumed

Mr. FLOBERG. The Commission has reported to the Congress frequently on the steadily increasing use of radioisotopes in agriculture, medicine, and industry.

In the interest of informing this committee of the current status of radioisotopes technology and application, we have submitted to you a special report on radioisotopes in science and industry. I believe the report will prove of considerable interest to you as well as bringing more fully to public awareness the ever-increasing influence of radioisotopes technology in so many facets of our daily lives.

The report illustrates the large range of possible radioisotope applications. I would like to mention elimination of agricultural pests as an example.

The radiation from radioisotopes has been the means for wiping out the screwworm fly from Florida and the southeastern United States, where ranchers formerly suffered $15 to $25 million annual loss due to this pest. Work is being carried out in this and other countries of the world to determine whether or not this same technique can be successfully applied to the elimination of other types of pests, such as boll weevil, fruitflies, oriental and melon flies. Insect damage to agricultural crops and domestic animals in the United States amounts to approximately $4 billion annually.

Chairman ANDERSON. We might call attention to the very fine publication, Radioisotopes, which was put out in January 1960 by the Commission. It is in good readable language and very usable form.

If people are not familiar with it, I hope they will become familiar with it because I think it is a very fine pamphlet and I congratulate the Commission on it.

Mr. FLOBERG. Thank you, Senator.

We feel it is particularly important to realize that while the basic principles of isotope use have been known for about 25 years and we have made important progress in certain areas of use, their broad application is, with limited exceptions, relatively unexploited.

In recognition of the benefits which can accrue from widespread use of radioisotopes, the Commission, late in 1958, expanded its isotopes program to put isotopes to work more fully for man's scientific and engineering progress.

The Commission, under its expanded program to develop isotope principles and technology, has established three objectives:

First, to fill the gap between basic and applied research in isotopes by carrying out developmental research;

Second, to reduce the timelag between conception of a new principle and its practical application; and

Third, to create a broad base of new and improved technology so that uses of radiosotopes and radiation in industry, in agriculture, in medicine, and in research can be extended and speeded up.

The Commission sponsors work aimed at these objectives by a number of regional university centers, by private laboratories, by our own national laboratories, and by a limited number of industrial organizations and other Government agencies.

Usually, the Commission carries forward the work only to the point of demonstrating the feasibility of a new principle for using the isotope; further development, such as engineering, becomes the responsibility of private industry. In special cases, the Commission may support development of a proof-of-principle working model.

We have now had a year's experience with the expanded isotopes program. Our emphasis has been placed upon developing technology, the technology of using isotopes and of applying radiation to industrial processes, as well as upon improving methods of radioisotope production and preparation. This program is supported by the addition of training courses for industry.

Much of the isotope technology we are studying will bear directly on problems of public concern, as in the areas of water resources, weather, air pollution, and industrial waste treatment and disposal.

During the past year, we have entered into research and development contracts covering a wide range of technical projects.

One example is a cooperative effort with the Weather Bureau to build an isotope-powered, unmanned weather station to continuously transmit weather information from remote locations. Weather data is a matter of universal interest and recently has become a common scientific meeting ground for all nations. The use of dependable, long-lived radioisotope power sources for unmanned weather stations would make possible a major advance in the science of weather predictions. This would permit continuous collection of weather data from regions, such as the Arctic, where it was previously impossible.

I have a small model of one of those here, Senator, if you would like to see it later.

Representative HOSMER. Mr. Chairman, I presume this has to do with the thermoelectric devices.

Mr. FLOBERG. Not in the sense of direct conversion, if that is what you meant. This is an isotope source that is wrapped up in a package and becomes a heat source.

Representative HOSMER. Thank you.

Mr. FLOBERG. An investigation of importance to atmospheric pollution determinations involves development of an analyzer for detecting contaminants in concentrations as low as 10 parts per billion. Under present procedures, data collection and analysis are slow and expensive to obtain. Smog control groups have emphasized their need for automatic, sensitive analyzers that will permit quick collection of data and implementation of control procedures.

Under the isotopes program, we are developing a unique analyzer using the fission product gas krypton 85 to measure directly the concentration of atmospheric contaminants such as sulfur dioxide and ozone. This principle would provide a tool that would assist control of this national problem.

The discovery, development, and conservation of water resources is a matter of primary interest not only in the United States but in many parts of the world. Problems vary from those of the arid zones of the world where the emphasis is on exploration, to those of highly industrialized regions where water demand has overtaken a previously adequate supply.

Radioisotopes offer tools for increased understanding of underground flow of water, and many more water resource factors such as rainfall, runoff, ground water recharge, and waste discharge. This, in turn, will provide better understanding of the effects of those factors on reservoir development, land use, flood control, and quality of water.

We have been working closely with U.S. Geological Survey and other groups in carrying out a systematic study of how nuclear techniques may be used in solving water resources problems.

The program on industrial process radiation aims at putting to work the energy of massive quantities, millions of curies, of ionizing radiation. Sources of such radiation are fission byproducts, reactor-produced isotopes, and nuclear reactors.

In this field we are exploring a basic scientific problem, the interaction of radiation and matter. Design of radiation sources for various specific processes is another broad area being worked out. Additionally, we will focus attention on processes including chemical, physical,

and biological changes of potential industrial interest that might be induced by ionizing radiation.

An example of the type of work which we are carrying out is initial research and development to establish the feasibility of producing chemicals with nuclear reactors, a reactor that might be described as a chemical factory.

For example, it has been demonstrated that when mixtures of nitrogen and oxygen, normal constituents of the atmosphere, are passed through the core of a reactor under certain conditions, nitric acid is produced. Production of other chemicals of importance in the national economy, and even new products not now in existence, are among the possibilities. However, we are presently only at the very earliest research threshold of developing nuclear reactors into producers of bulk chemicals.

Massive quantities of radiation energy may also be a means of converting coal into valuable new chemicals, and, accordingly, develop new markets for coal products.

The Commission and the Bureau of Mines have therefore entered into a cooperative agreement for conducting research and development on beneficial radiation effects on coal and other natural resources. The Commission is providing a 100,000-curie cobalt 60 source for this project and will provide technical assistance.

The Bureau of Mines is providing the necessary facilities and equipment and will carry out the experimental work. We believe this research may result in determining means of improving the utilization of the Nation's coal and other resources.

Under the program for production and process development, radioisotopes and radiation sources are produced in Commission facilities to meet the changing needs of advancing science and tcehnology. In pricing of radioisotopes, our objectives are to provide reasonable compensation to the Government, stimulate private sources of isotope supply, and encourage research and development.

During the year the Commission substantially increased the quantities of tritium and krypton 85 for civilian use, 1 million curies of tritium and 100,000 curies of krypton. Studies performed during the year also have established the economic feasibility of producing radioisotopes in power reactors.

To provide increased opportunities in isotope technology training, the Commission established a special industrial radioisotope course at Oak Ridge. During 1959, three 6-week courses were attended by 100 industrial scientists and engineers.

Among other educational activities, 7 regional workshops on the industrial uses of radioisotopes were attended by more than 1,500 scientists and engineers.

That concludes that portion of the prepared statement.

Representative DURHAM (presiding). In paragraph 152 you state that the Commission substantially increased the quantities of tritium and krypton 85 for civilian use.

Is there any license advantage for us in that?

Mr. FLOBERG. This refers to the set-aside by the Commission of these quantities of isotopes.

Whether there have been any actual licenses issued after the set-aside, I would have to ask Mr. Price.

Representative DURHAM. You are speaking to the industrial uses and of the great benefit to a greater population. That is the reason I asked the question.

Have you granted any licenses or have there been any requests for licenses for krypton and tritium?

Mr. FLOBERG. I would like to ask Mr. Price to answer that. He is the Director of Licensing and Regulation.

Mr. PRICE. I don't have any figures that relate to the number of licenses to these particular set-asides, but I can get them for the record. There are outstanding about 5,500 isotope licenses.

Representative DURHAM. I am not speaking about isotopes. I am speaking about tritium and krypton.

Mr. PRICE. Yes, sir. These licenses would include licenses for tritium and krypton.

Representative DURHAM. It would include those?

Mr. PRICE. Yes, sir.

But I don't have a breakdown that relates the number to these particular set-asides of material. I will be glad to try to get it for the record.

Representative DURHAM. Thank you very much. It will be printed for the record.

(The information referred to follows:)

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., March 15, 1960.

Mr. JAMES T. RAMEY,
Executive Director,
Joint Committee on Atomic Energy,
Congress of the United States.

DEAR MR. RAMEY: During the 202 hearings on February 17, 1960, Mr. Durham requested Mr. H. L. Price to supply information as to the number of licenses which have been issued by the Commission for krypton 85 and tritium. This will inform the Joint Committee that the Commission has issued 197 licenses for krypton 85 and 515 licenses for tritium.

Senator Anderson inquired as to the number of personnel in the Divisions of Licensing and Regulation and Inspection. There are at present 97 employees on the Licensing and Regulation Division's staff, and 80 employees on the Inspection Division's staff.

Sincerely yours,

R. E. HOLLINGSWORTH,
Deputy General Manager.

Representative DURHAM. Does that complete your part of the statement?

Mr. FLOBERG. Yes, sir.

Commissioner Graham will read the portion of the statement on the regulatory activities if you have no further questions on this portion.

Representative DURHAM. Are you ready to proceed?

Mr. GRAHAM. Mr. Chairman, can we have just a moment's break to change the cast of characters here?

Representative DURHAM. Very well.

STATEMENT OF JOHN S. GRAHAM, COMMISSIONER, AND STAFF MEMBERS, ATOMIC ENERGY COMMISSION

Mr. GRAHAM. Thank you, Mr. Chairman.

In coming to this regulatory activities, Mr. Chairman, a little further along I want to introduce to you, if I may, Mr. William F. Finan, formerly Assistant Director for Management and Organization of the Bureau of the Budget. He has been with us for the past few months, and the units involved in his activities are the Division of Licensing and Regulation and the recently formed Office of Health and Safety.

Chairman ANDERSON. You may do so whenever you wish.

Mr. GRAHAM. I would like to ask him to put some charts up on the easel here, Mr. Chairman, and get him to explain to you the change from the old to the new form of regulatory activities that we have been concerned about here.

Chairman ANDERSON. We are ready any time you are.

Mr. GRAHAM. Thank you, sir.

Returning to item 154 of the prepared text, Mr. Chairman, in all of the Commission's regulatory activities, protection of public health and safety is paramount. Our aim is to provide such protection through simple and economical processes which impose a minimum burden upon those who are regulated.

Many of the Commission's regulatory activities were based upon plans necessarily developed in advance of practical experience. Based on growing experience, we have initiated steps to: (1) Realine our organization for regulatory activities; (2) clarify and simplify our regulatory procedures; and (3) refine our safety and health criteria and standards, particularly those bearing upon construction and operation of the very large reactors, the power and test reactors.

Chairman ANDERSON. Has the regulatory function become any sort of burden on the Commission?

Mr. GRAHAM. Mr. Chairman, I can say that we take it seriously. We work at it rather diligently. It will be a growing burden because there will be more and more of these coming in. I couldn't say to you, sir, that it is the straw that broke the camel's back. I couldn't say that.

Chairman ANDERSON. I was just thinking when you are struggling with the reactor program for the next 10 years, what it feels like to get back and decide how you should handle a waste problem at Houston or Galveston or some other place.

Is that not somewhat different?

I am getting ready to ask a second question; how much time is spent in the regulatory matters?

Mr. GRAHAM. In the Houston case, sir, we had a full day's hearing on that. We will now have to go through and read the record and come together and decide who is going to write the opinion, and then go ahead and do that.

If I can analogize by treating these decisions in these cases as if we were in the Supreme Court, and we try to do this work very conscientiously, sir.

Chairman ANDERSON. You say, just like you were in the Supreme Court. Therefore, this part of the work is sort of quasi-judicial?

Mr. GRAHAM. Yes, sir.

Chairman ANDERSON. Whereas, the development of weapons and the development of reactors for power is quite a different story?

Mr. GRAHAM. Yes, sir; it certainly is.

Chairman ANDERSON. I have made an observation once or twice that maybe we ought to study whether a separate board for regulation or licensing might profitably be set up.

Generally speaking, there is a difference between these judicial functions and the ordinary functions of trying to promote and develop the use of atomic energy. I just wondered if you have given any thought to the splitting off of those functions which are purely regulatory or might be termed judicial from the things which are quite separate from that.

Mr. GRAHAM. Mr. Chairman, you are exactly right.

It seems anomalous in many respects to have us wearing a promotional hat and also a regulatory hat. At some point in time we try to draw the distinction of a cutoff point, where it goes to trial, if I may use that analogy, treating the hearing examiner as a Federal district court judge to take the evidence and render his opinion, and then it comes to us on an appeal, if I may think about it in those terms.

Chairman ANDERSON. As the Supreme Court from the U.S. district court?

Mr. GRAHAM. We try to think about it in those terms.

Chairman ANDERSON. What I am getting to, Mr. Graham, is, suppose that if in this country when they started to build transcontinental railroads there had been an agency whose job it was to develop a program for transcontinental transportation by railroad: land grants, engineering.

You may recall how many surveys there were of routes to the Pacific. It runs into 15 or 20 volumes of big studies. Simultaneously, while the group was trying to promote, suppose they had also been the ICC, the regulatory board to decide what rates the railroads might charge, how many flagmen and switchmen and so forth they were going to have, what sort of rules they were going to abide by.

Here they would be pushing it ahead with one hand and holding back with another. I think that would have been regarded as sort of ridiculous.

I wonder if there is not going to come a point in the work of the Commission at which the regulatory and licensing functions might be split off from those functions which deal with the development of isotopes and the planning of atomic power plants in Antarctica, or some place of that nature.

If some thought has been given to it, I would like to have it and I am sure the members of the committee would.

Mr. GRAHAM. Mr. Chairman, I am sure all of us think about it from time to time. I believe you are forecasting, as you have done before in so many instances, that this time will come. I would not be prepared to say to you today that it is here.

But to repeat, it is something that is in our minds just as it is in yours. I think sometime it is something that your committee and your staff and the rest of us should take another look at. You have not looked at it for, I believe, for 2 years.

Chairman ANDERSON. How many people do you have in this licensing division?

Mr. PRICE. There are about 105.

I will correct the figure, but it is a little over a hundred.

Chairman ANDERSON. Regulatory and licensing, or just licensing?

Mr. PRICE. This is licensing and regulation. This does not include inspection.

Chairman ANDERSON. There are about 100 in licensing and regulation?

Mr. PRICE. In licensing and regulation, slightly over a hundred.

Chairman ANDERSON. How many in inspection?

Mr. NELSON. About 60 professional people, including the field. (See letter, p. 96.)

Mr. TOLL. Mr. Graham, it should be pointed out perhaps that the Commission has made some steps in the direction of separation of powers and that perhaps some more could still be made before the ultimate separation or creation of a new agency was made.

Do you think it would be possible to make some more steps still within the organization to separate out the regulatory functions.

Mr. GRAHAM. Mr. Toll, I think we are here to try to answer some of those questions of what we are now trying to do.

To repeat, if I may speak as a lawyer, and to analogize, we try to think of the hearing examiner as being in effect a Federal district court. When you have your case ready to present the evidence to him, he is ready to receive it and to render the decision. From that it either comes to us as the appellant court on an appeal or we take it ourselves to see if we want to remand the case for further hearing.

I can speak only in terms of the analogy here, but at least we are conscious, if I may put it this way, of the need for public hearing and the production of the evidence on the record.

Mr. RAMEY. Following your analogy a little further, you have in the Federal court system a circuit court of appeals where most of your cases are finally settled. I think one of the things we were looking at in the committee staff study a couple of years ago was perhaps that you ought to have some intermediate scheme of a board within the Commission that would decide cases without their having to go all the way up to the Commission. That would be over your hearing examiner.

Mr. GRAHAM. I used the words, the analogy of the appellate court, in this sense, that we do try to look at the record to see if the case is made.

In one case where we did not think it had been completely made, we remanded it and asked for further evidence. I suppose if you want to put it this way, beyond us there is an appeal to the real Federal court. There is a case pending there now.

Chairman ANDERSON. Mr. Ramey and Mr. Toll are both lawyers and they understand what you are talking about. I was just kind of curious if there was not some chance of getting a legal separation before we got an actual divorce.

Mr. GRAHAM. Mr. Chairman, they are very good lawyers, too, if I may say so, and this is why I suggested that since they had not looked at this for a couple of years that maybe it would be time to

sit down and take another look, because the load will get greater as the time goes on. It is not a closed matter.

Chairman ANDERSON. Go ahead.

Mr. FLOBERG. May I make one comment on this point on the record?

I thought before I ever came on this Commission, and when I was practicing law here in town, that the margin between the promotional and the judicial functions was an unnatural one, and I thought it with regard to other administrative agencies in town before I knew anything about the Atomic Energy Commission. I have long thought that this was a poor method of organization, and I think the bar generally is critical of this measure as regards all the administrative agencies in town.

I might add that my experience on this Commission has done nothing to change my opinion in that regard. On the contrary, it has fortified it.

I think you are putting your finger on this particular agency because you have experience with it directly. But I think the observations that are made on this subject with regard to this agency can be made with regard to almost any other quasi-judicial agency in town.

I hope that this committee may trigger some action that will have more universal application than just with regard to this Commission.

Chairman ANDERSON. Thank you.

Representative HOSMER. Are there other areas in the Commission organization that ought to be examined or reexamined? Is it a general sort of thing that we ought to go into and see if the organization still fits the need, or would you just stop with the regulatory activity?

I am asking you, Mr. Floberg, because you seem to have been alert to organizational matters.

Mr. FLOBERG. I am just talking about this one particular problem at this moment.

Representative HOSMER. Since you have been on the Commission, have you noticed other things that ought to be taken up in course and examined and handled possibly by changes in the law.

This is a kind of a hooker, but since you opened up the door we might as well ask your opinion.

Mr. FLOBERG. We just went through a study here on other organizational changes, and I have plenty of ideas if I were king and I could implement; yes, sir.

I think that the basic organization of the Commission in other respects is pretty good at the present moment. But is is always subject to revision.

I do think that this one particular philosophy that has gone through the administrative agencies for some 20 years now is one that should be scrutinized, however.

Representative HOSMER. In short, you decline to state?

Chairman ANDERSON. He gave you the railroad sign, "Proceed with caution."

Mr. FLOBERG. I am not taking the fifth, Mr. Hosmer.

I think we did go through t pretty comprehensive combing within the last year. I don't think this is a subject that is ever completed. It is just temporarily suspended.

Representative HOSMER. Thank you.

Chairman ANDERSON. I did not try to get into this an argument of any kind. It does seem to me as you go on with your work you are going to some day come to the point where the regulatory, the licensing thing, ought to be split off from the other things, because they do seem to be distinct functions and we would like to have the thinking of the Atomic Energy Commission along that line any time you care to submit any ideas to us.

Go right ahead, Mr. Graham.

Mr. GRAHAM. Thank you, Mr. Chairman.

I have spoken about Mr. Finan, which covers section 156, so I shall go on to section 157.

Direct inspection of licenses for compliance with regulations will be transferred from the Inspection Division and placed in a new Division of Compliance under the Assistant General Manager for Regulation and Safety. The Inspection Division will, of course, retain its overall statutory responsibilties.

The already heavy workload of the Advisory Committee on Reactor Safeguards undoubtedly will continue to grow.

Interpolating, Mr. Chairman, this is bound to grow just as the work you spoke of in the whole regulatory field will do, as these reactors increase in number.

To enable the Committee to handle this workload, the Commission and the Advisory Committee on Reactor Safeguards are working together to simplify and strengthen working arrangements between the Committee and Commission staff.

Chairman ANDERSON. Could you give us the amount of time spent on an application, one like the Yankee reactor or Commonwealth Edison or Consolidated Edison?

Are there any estimates you can give us as to how much of the Commission's time these things take?

Mr. GRAHAM. Mr. Chairman, they have a very high-class group on the Reactor Safeguards Committee. I believe they try to meet at least quarterly. They do have quite a long agenda. They work diligently, and I believe sometimes far into the night.

Chairman ANDERSON. Yes; I am sure of that.

Mr. GRAHAM. They are an extremely helpful group, as you know.

Chairman ANDERSON. Thank you.

Mr. GRAHAM. The steps we are taking to improve procedures are directed particularly toward licensing of large power and test reactors. Experience with our early regulations have proved them to be too general. They are silent on some points in which prospective licensees and the public need information. The Commission on February 11, 1960, published for public comment in the Federal Register three proposed regulations modifying its reactor licensing policies and procedures.

The first proposed change would define the point at which a permit for reactor construction must be obtained. It would allow component procurement, site acquisition, and clearance and excavation, but

not the pouring of foundations, before issuance of a construction permit.

Representative HOLIFIELD. At that point why do you allow private industry to take on the obligations of buying the land, clearing and excavating, and all that sort of thing, when they have no assurance that they will receive a construction permit?

Mr. GRAHAM. That is a good question. It is a matter of judgment. It seemed to us that when you prepare your land and you can go on with certain site acquisition, that this usually takes some period of time, and it has been our experience that they can be doing that while they are firming up some of the design details and the last bit of work they should do before they are ready to come in.

Representative HOLIFIELD. But they have predicated certain moneys for these purposes before they even come to you for any evaluation of their reactor concept and the safety of it. That has gotten you in trouble in the past by allowing these companies to locate these reactors close to big centers of population without giving them their operating permit. It seems to me that this whole thing ought to be looked at very carefully and that the first step that any company should make would be to get the approval of the type of reactor they want to build and know that they have got that and then go out and get their land and spend their money for their land and excavation and procurement of component parts for a reactor.

Mr. GRAHAM. Their commitments could be for the turbines or the long leadtime items. It could be perhaps for a pressure vessel. I think the point that we are trying to draw here, if I may say so, Mr. Holifield, is that once you start pouring concrete that affects the design of your plant and sometimes that design has not always been worked out. They may be in the process of doing it as they go. It is this part that is a little difficult for the Government agency to say: "You won't even clear your land, or won't let you do any preliminary work without getting a full construction permit."

Representative PRICE. Didn't you tighten up a little on that in the last couple of weeks, that you definitely stated that there would be no construction permit approved or granted in the future until after the situation had been definitely approved?

Mr. GRAHAM. What we have published for comment, sir, is to say that if you start pouring concrete, at that point in time you have to have a construction permit.

Representative PRICE. Yes.

Isn't there something new that you did in the last month or so in that regard which definitely made it known that there would be no construction permit granted until they had gone through the process of definitely approving the situation? Is that right, Mr. Price?

Mr. PRICE. The regulation that he is now talking about plus the next one accomplish that purpose; yes.

Mr. RAMEY. On this point that was raised here, has the Commission had any instances where an applicant has started to pour concrete or do things beyond the stage that the Commission has set up in this proposed regulation as it stands?

Mr. GRAHAM. It is my recollection that we had one rather difficult case, Mr. Ramey, some months ago. The reactor in question was, let me just use the terminology of a proven type or a standard type,

which would not have given the reactor safeguards people any particular problem. Then they came in with a proposal to add something else on to it. This had not been fully designed, had not been worked out, and it was on this point that you could not say, with the new gadget added on, that you could draw the conclusion of reasonable assurance that this would be safe from the standpoint of health and safety. This is what gave us a great deal of difficulty. It was this rather dramatic experience which caused us to take a new look at this.

Chairman ANDERSON. Is there any reason for not naming the case?

Mr. GRAHAM. It was Northern States Power.

Chairman ANDERSON. Yes. It is now straightened out?

Mr. GRAHAM. I think we have straightened it out up to the point of the old design, and the new design will have to come in and be fitted in.

Representative HOLIFIELD. Mr. Chairman, I think this whole subject here is quite important, the approval of sites and so forth, prior to the issuing of licenses. I hope some time—I don't know that this is the time, and probably it is not—Mr. Roger McCullough will be called before our committee to give us some additional information on this.

I have long felt that this field should be handled like it has been handled in England, if I am correctly informed. In England the first thing that is done is to obtain the approval of the site in relation to the type of reactor that is to be built by their group, and then they start out.

I seems, from a safety standpoint, this would be a protection to the businessman. Let us take the PRDC. There is still a lawsuit in regard to the site on PRDC at Lagune Bay. That is the one that has gone to the Supreme Court.

Mr. GRAHAM. It has gone to the circuit court. I think it is to be argued on March 14.

Representative HOLIFIELD. Yes.

There is also some question as to the safety of this type of plant in that particular location. The fact that they have ahead and put many millions of dollars into it, it would work a tremendous hardship on them if this was found to be unsafe. And, yet, the protection of the people might cause just that sort of thing to happen.

This granting of a construction permit and then, finally, granting of an operating permit, it seems to me, causes private industry to take a terrific gamble. The pressure becomes so great to grant the operating license, because of the financial investment, that I am wondering if a body, which in this case is not a separate body but a part of the body that granted them the first steps in their procedure, is not put in a very bad position, to deny them at the last moment in the public interest an operating license.

As I see you begin to pull these things together here I am hopeful that some procedure can be evolved that will be fair to industry and, of course, protect the public at the same time.

I recognize, in going into a new field like this, you have a problem. I am not unaware of the fact that we are experimenting here. But the very fact that we are experimenting and that there is a possibility of an unsafe plant when it gets to the finished stage, and the pressure

to allow it to operate and so forth, it seems to me those points ought to be resolved ahead of time.

Mr. GRAHAM. It is a difficult problem, Mr. Holifield. I think we are making some progress. If I can go on from here, I think we are trying to show some of the steps we are taking.

Chairman ANDERSON. Go ahead, Mr. Graham.

Mr. GRAHAM. The second proposed change in the regulations would clarify the requirements to be met for issuance of construction permits recognizing, however, that most decisions must be based on case-by-case considerations while the developmental stage in reactor technology continues.

Permits may be issued on a provisional basis if there is reasonable assurance that the proposed site is suitable from a safety standpoint for a reactor of the power level and general design concept proposed. This may be done, even though there remains to be performed research and development work on some design questions affecting safety, upon a showing that the applicant will conduct a research and development program on these questions. The applicant may apply at any time for an amendment to his permit granting approval of satisfactorily resolved design features.

Chairman ANDERSON. As I understand this, Mr. Graham, you say this is done on a case-by-case basis, and paragraph 160 refers to Northern States Power, paragraph 161 refers to the PRDC.

Mr. GRAHAM. At this point, Mr. Chairman, could we put up these two charts on the old construction and the new, and perhaps this?

Chairman ANDERSON. 162 relates to Commonwealth of Chicago. So what you are saying, it seems to me, is that we learn these things by experience, and, case by case, we try to find the things we have to do to make this regulation work.

Mr. GRAHAM. I think perhaps the best description I can give of the problem was expressed the other day in our meeting with the reactor safeguards people. They were saying each one of these new reactors has something new or novel in it. So long as you do have that, you have this design problem that I have mentioned earlier with respect to the Northern States power companies.

It is not as though you had a body of experience in these large reactors such as you might have in the small research reactors, for example, and you are moving on a step-by-step basis.

If I can still use an analogy, you may be designing as you are still building.

If I can still quote them, they don't quarrel with this kind of approach because you are trying to improve the art, you are trying to make some new steps, and, in the words of the joint committee, you are not trying to have just carbon copies.

If all of us recognize what the problem is, how you are trying to go and what the limitations are, I think maybe it will give all of us a little more of a feeling of what we are trying to grapple with. It is on this point that I used the words of a case-by-case basis because we just don't have the experience.

Could I ask Mr. Finan to talk about the old provisional construction permit and the new one, bearing in mind the observations which I have just made here of what the problem is as we see it.

Mr. FINAN. I hope these charts are legible from this distance. We set them up in parallel columns so that you can follow them.

STATEMENT OF WILLIAM F. FINAN, ASSISTANT GENERAL MANAGER FOR REGULATION AND SAFETY, ATOMIC ENERGY COMMISSION

(The charts used by Mr. Finan appear in appendix 12, p. 677.)

Under current regulations the criteria for the issuance of a construction permit, briefly stated, are, first, a reasonable assurance that the facility of the general type proposed can be constructed and operated at the proposed location without undue risk to the health and safety of the public.

You will note there is an inference in the current regulation that the problems involved in safely operating the facility can be adequately reviewed and taken into account at the time the construction permit is issued. Experience has indicated that is asking both the applicant, the Commission, and, for that matter, the ACRS, to go farther than technology actually permits at this time.

So the criteria in the proposed regulation is reasonable assurance that the proposed location is suitable from a safety standpoint for a facility of the size and general design concept proposed.

Chairman ANDERSON. You take the reactor completely out of it. It is just a question of the site?

Mr. FINAN. No, sir. It makes the reactor issue one of whether its size and general design concept would make it suitable for the site. It admittedly leaves open certain specific features which are to be the subject of research and development and to be worked out concurrently with the construction of the reactor.

Chairman ANDERSON. Let us read it again.

Reasonable assurance that the proposed location is suitable from a safety standpoint for a facility of the size and general design of the concept proposed.

Mr. FINAN. Yes. This marries a consideration of the site to the general type of reactor that is contemplated, and no more at this stage, in order to get a construction permit. Plus, of course, three more criteria that also must be applied and must be used, two of which are the same as we have now.

We remove this element in here that this reactor can, in fact, be operated as contemplated at that time.

Chairman ANDERSON. I see. You remove it.

First, you say you have to have reasonable assurance that the facility is safe. This puts it that the site is safe.

Mr. FINAN. The site is safe for a reactor of the general size and design concept that is proposed by the applicant.

As you know, Mr. Chairman, far better than I, there is a direct relationship from a safety point of view between the site and the type of reactor. There are some sites in the world where most any kind of a reasonable reactor could be built with safety, and there are others where, from an economic point of view, they are probably ruled out. At least, they are at this stage of the game. But the two always have to be considered together.

Mr. RAMEY. Does this make it easier, to loosen it up some, than the way it was before?

Mr. FINAN. I don't know whether you would call it easier or whether you would call it loosened up.

On the basis of the experience the Commission has had to date, it comes closer to meeting the facts of the situation.

Representative HOLIFIELD. Has it moved toward the English method of approving the site first? You are transposing, as I see it. In one case you ask for more information on the facility, and require reasonable assurance on that. In this case you have your reasonable assurance that the site is suitable. You are kind of twisting words there, and I am not sure what you mean.

What do you relieve the Commission of in this new criteria? Do you relieve them of any obligation to issue a construction and operating license by this change?

Mr. FINAN. It enables the Commission to issue a construction permit with, let us say, a clear set of ground rules laid down at that point which are understood by the Commission, its staff and by the applicant, of what the unresolved safety issues are which must be satisfactorily resolved before the applicant can ever expect to actually operate this reactor.

Chairman ANDERSON. You drop out all reference to the health and safety of the public?

Mr. FINAN. No, sir.

Chairman ANDERSON. I read it in one place and do not read it in another.

Representative HOLIFIELD. Suitable from a safety standpoint.

Mr. FINAN. You have to look at all four criteria.

There actually will be five criteria in the new regulation. You have to fit them all together to see exactly where we come out.

The old criteria, the No. 2, is reasonable assurance that technical information required to complete the application will be supplied by the applicant. For that we substitute the major features or components on which further research and development work is needed to assure the safety of the facility. This is a substitution.

Mr. RAMEY. Isn't that loosening it up some?

Mr. FINAN. Three and four are the same.

Mr. RAMEY. Isn't the difference between those?

You say you just identify the research and development work that has to be done.

Mr. FINAN. Then you get down to 5. The fifth is a commitment by the applicant that he will conduct a research and development program to investigate the unresolved safety question.

Mr. RAMEY. Again that he will conduct the program. But, as I read the existing criteria, not only do you have to conduct a program and identify the things they have to work on, but you have to have some assurance that you expect it to come out safe.

Mr. FINAN. At the time these start—and this has been true in the past—everybody hopes and expects that the research and development program will be a success.

Chairman ANDERSON. Why don't we just apply this to the PRDC case. In item No. 2, at Laguna Beach, you would say there are these factors that need to be identified and we identify them as follows:

No. 1, they haven't done this; 2, they have to test this; and so forth and so on. Then you get down to the fifth requirement and say the applicant will conduct a research and development program to investigate the unresolved.

He doesn't have to solve it. He has to look at it.

Mr. FINAN. If he does not solve them, he will not get an operating license.

Chairman ANDERSON. Where does it say that?

Mr. FINAN. If it doesn't say it on this chart, Mr. Chairman, it is implicit in everything I have said.

Chairman ANDERSON. If it is implicit, why not say it?

Mr. FINAN. The regulations take care of that.

Chairman ANDERSON. Where in the regulations?

Mr. FINAN. In the proposed regulations that are now out in public.

Chairman ANDERSON. The other one says issuance of a construction permit would not be inimicable to the common defense and security and health and safety of the public. That is the guarantee on one side. That is the present guarantee. The new?

Mr. FINAN. No, sir. This is also here; these are identical, three and four are identical. They are retained.

Mr. RAMEY. Under two, isn't there an implication in your present regulation that in order to grant a construction permit now there must be reasonable assurance that the research and development program will provide adequate information to solve the safety problems of the reactor. Isn't that missing from your revised one?

Mr. FINAN. No; I don't believe it is.

Chairman ANDERSON. In other words, that this safety program will be successful.

You say no it isn't, and I would guess yes, it is. This would look, on the face of it, as if this is a way of getting around the PRDC case, that they don't have to come up and cure the things. All they have to do is take a peek at them.

Mr. FINAN. No, sir.

The fact is that PRDC is now constructing under the present regulation.

The issue is what is required to get an operating license.

Chairman ANDERSON. They are constructing, but somehow they are in court.

Mr. FINAN. Yes.

Chairman ANDERSON. This would say you can't take them into court because they are doing what you say. They have figured out the things that are dangerous, and they have agreed to investigate them. They have not agreed to solve them. They have agreed to investigate them. So give them the permit. Why hold them back? They have agreed to all the things that the criteria call for. It calls for an investigation.

Mr. FINAN. I don't know how far we can go here in talking about a matter that is under litigation.

Chairman ANDERSON. I don't either, but, not being a lawyer, I don't have any hesitation.

Mr. FINAN. One of the arguments on one side of this case is that we are in court prematurely, that these issues would throw it into court when the operating license came up rather than the construction permit. In other words, the same point you are making under existing regulation, as I understand it.

Representative PRICE. Let me try to think it out.

The No. 2 provision is the one you feel tightens up the regulation, in that you are going to be reasonably certain that the situs of the

location is suitable for the general type of reactor. Before you go to a provisional construction permit, the features of the components that might be questionable from a safety standpoint are definitely identified. So you are not groping in the dark. You know what you are worried about. Then, before you issue a full-fledged permit, these points have to be resolved.

Is that the situation?

Mr. FINAN. That is correct. The applicant can either come in as he successfully solves these listed problems and get his construction permit amended so he is clear on the item, or he can wait until he is all through and come in with one proposal.

Representative PRICE. Under the old criteria you could have issued the permit without the areas of doubt being clearly identified. There could be doubt in there that you would not have identified.

Mr. FINAN. We could have, as I understand it. I am very new to the Commission, but my understanding is that the Commission in fact did not. It could have been done.

Representative DURHAM. In No. 2 why did you use the word "major?" Why didn't you say features or components requiring further research? Somebody is going to have to say what is the major feature. How will we determine that major feature?

Mr. FINAN. The issue of whether the item is or is not major will depend on whether it does have some important connection with the question of whether the reactor can be operated with reasonable assurance that it is safe.

Representative DURHAM. I would think you could cover the whole reactor with one word.

Chairman ANDERSON. What purpose does the word "major" serve? Is it screening to take out certain sections, or isn't it?

Mr. FINAN. Sir?

Chairman ANDERSON. Is the word "major" for the purpose of screening out a lot of minor objections? It is pretty hard to tell.

I imagine that the Dresden plant, which is now in operation, the little things that are considered major now would not have been considered major earlier.

Mr. FINAN. To the extent that they are part of the control system, that whole feature was regarded as major, and still is. In other words, it makes no difference to us Mr. Chairman, whether for want of a nail the shoe is lost.

Chairman ANDERSON. If you leave the word "major" out it doesn't make any difference.

Mr. FINAN. Again, unfortunately, we are talking about a group of charts which is an effort to condense what is in the regulations. We are not talking about the direct wording of the regulations. The point we are trying to get across, Mr. Chairman, is that we will identify the important items and there will be limitations in the construction permit that will have to be later formally removed before the provisional character of the construction permit is lost.

The point we wanted to make clear to you is that we were not going to concern ourselves with every possible small nut and bolt in the project in this manner. That is all that the word "major" means.

Representative DURHAM. In No. 1 you say reasonable assurance that the proposed location is suitable from a safety standpoint for a facility, period. Then you would have it tied down and go on to the design of the concept proposed.

Chairman ANDERSON. There are two things I would like to suggest. One is that I would like to have Dr. Rogers McCullough come here and, from his experience, tell us what he sees in these two charts. Scondly, I would like to suggest that whoever is responsible in this field for the AEC get together with the staff of the Joint Committee and see if we cannot study what these things mean in the light of the regulations you already have.

I am frank to say I do not know, and I do not think any of the rest of us know.

Rather than argue about the language of this chart, I remember what happened when the man tried to rewrite the Ten Commandments—we would probably have trouble rewriting these here today. Some of us are going to try, but it may not be too significant.

Maybe we ought to let these charts go, let Mr. Graham finish his testimony, and let the staff try to work out with your staff, if that is agreeable, General Luedecke, some of this information.

If you will get in touch with Mr. Ramey and Mr. Toll and other members of our staff, whether it may be necessary, and let us understand what this is, we probably will save time for the whole group.

Mr. GRAHAM. I think that is a very good suggestion, Mr. Chairman.

We did want to bring them to you and just emphasize that this was out for public comment on February 11. We did discuss them informally with Dr. McCullough and his group. He thinks it is a step in the right direction. We did not ask him or his group to approve them beforehand. They will comment on them, as will others, when they are out. We certainly want their comments and suggestions, and also from the Joint Committee.

Chairman ANDERSON. We will try to work it out.

Go right ahead.

Mr. GRAHAM. Thank you, sir.

Chairman ANDERSON. Suppose you start with 165.

STATEMENT OF JOHN S. GRAHAM, COMMISSIONER, AND STAFF MEMBERS, ATOMIC ENERGY COMMISSION—Resumed

Mr. GRAHAM. Yes, sir.

Several years ago the Commission established detailed health and safety standards relating to permissible exposures to radiation. Based on revised recommendations of the National Committee on Radiation Protection and Measurement, the Commission some months ago issued for public comment proposed changes in its regulations. In view of the extensive public interest and numerous suggestions received, the period for public comment was twice extended, and further revisions are being made in the proposed amendments.

166. Last February the Commission amended its regulations to provide a simplified licensing procedure applicable to the use of gaging, measuring, and controlling devices containing radioisotopes. It is the Commission's experience that many of these devices can be designed so that they may be safely operated by persons not trained in radiation protection. Under the amended regulation, the user does not have to apply for a specific license, provided that suppliers obtain specific licenses authorizing the manufacture and distribution of the devices.

167. Within the near future, the Commission expects to seek public comment on two proposed new regulations containing safety criteria,

one covering the use of radioisotopes in radiographic operations, the other establishing standards for the shipment of irradiated fuel elements.

168. In the field of power and test reactors, we published last summer a notice of proposed rulemaking to prescribe factors considered in site evaluation. The proposed regulations were the result of considerable staff study and consultation with the Advisory Committee on Reactor Safeguards. Comments and suggestions were invited on the site factors, and on possible development of definitive site criteria, which might be incorporated in the Commission's regulations. A substantial number of comments indicated that the guidance intended by the proposed regulation is desirable. Many stated, however, that quantitative site criteria should not be prescribed by regulation at this time because the reactor industry is new and the factors associated with siting too variable.

Representative HOLIFIELD. What do you mean by "quantitative" in that comment?

Mr. GRAHAM. What we mean there, Mr. Holifield, is that many of the reactor people, where you have the novel features which we have been talking about, object if you tried to pin them down in regulations. Instead they favor, let us say, the informal type of criteria that you use, when you get it into the reactor field. If these criteria get embedded in regulations, and if you have to change them on the next go-round, it will take forever to get them out. I think this is really the chief objection.

Representative HOLIFIELD. Did that theory come from the reactor manufacturers rather than the reactor safeguard committee?

Mr. GRAHAM. I think the reactor safeguard committee has some question about putting it into regulations, sir.

Representative HOLIFIELD. Did the suggestion that you not go into a quantitative field come from the reactor manufacturers or from the safety committee?

Mr. GRAHAM. Let me ask Mr. Price.

Mr. PRICE. I think the correct answer is both. I think the safeguards committee feels that it is a little bit early to be putting numbers down.

Chairman ANDERSON. They had very permissive numbers; didn't they?

Mr. PRICE. Yes, sir.

Chairman ANDERSON. This objection came from the industry; did it not?

Mr. PRICE. I am going to answer that part of the question, too, Senator.

Chairman ANDERSON. This was going to be something within about 10 to 40 miles, and the industry did not like that.

Mr. PRICE. They didn't like it at all; that is right.

Chairman ANDERSON. That is right.

Mr. PRICE. But I think it is fair to say that the safeguards committee also probably is not too enthusiastic with using definitive numbers at this time.

I think we can satisfy the safeguards committee. I don't know whether we can satisfy industry or not. But we can certainly develop some guides here on site criteria.

These numbers that were talked about, that were objected to, are the numbers that we put in this proposal that related to exclusion distances and distance from populated, densely populated areas. That is where the argument is, as to how definitive those numbers ought to be.

Chairman ANDERSON. But you came up with a measurement of 10 to 40 miles from a densely populated area.

Mr. PRICE. I think we used a minimum of 10 to 20 for large power reactors, and we didn't put an upper number on it.

Representative HOLIFIELD. This illustrates again, Mr. Chairman, the contradictory position which the Commission finds itself in. They are anxious, and the committee is anxious to have reactors built.

You enter into this problem: If you require 50 miles, you lose a certain amount of electricity in transmission, and therefore it affects the economics. On the other hand, if you put it 10 miles, you may be putting the reactor where it is not safe, at the 10-mile spot, where it would be perfectly safe at 50.

You have this conflict continuously, and you are on both sides of the table. You want to build the reactor, you want to issue the license, we want you to do it, and the plant people want it to be economic, and we want it to be economic, but then comes the conflict. It is a safety conflict. That is why I asked the question about putting down definite, quantitative figures in these regulations.

If you surrender completely on that point, what you are doing, of course, is trading safety for dollars. I am not saying you are doing it, you understand.

Mr. PRICE. I think it would be fair, Mr. Chairman, to say that one of the main troubles with these numbers is that there are so many other factors besides. This is a complex problem. There are so many other factors that relate to whether a site is all right that you don't just solve it by saying 50 miles or 20 miles. That is one of the difficulties.

Representative HOLIFIELD. No; you don't because the different reactors have different degrees of safety, built-in safety and built-in hazards. I understand that point.

We are bringing electricity several hundred miles from the Boulder Dam to Los Angeles, for instance, and I think where the safety of the public is involved, that is of more importance than locating a site 10 miles from an area or putting it 50 miles from a population area, at this stage of our reactor experience.

Mr. RAMEY. Each year now, I think for about the last 4 years, the committtee always raises the question on when you are going to have your safety criteria developed, and the other question always is what about providing for alternative sites when you are going into these regulations. That is in relation to your provisional construction permit criteria. If you had a provision for alternate sites, then it might make more sense having provisional criteria. But if you have just one site to look at, then it ought to be a very safe site.

Mr. GRAHAM. I think you are right, Mr. Ramey. And it is desirable if there can be alternate sites.

I believes sometimes a utility may not have that much leeway. I think Mr. Holifield has summed up the dilemma that we are faced with. Where we do have to look, in the final analysis, at the public

health and safety. In all of these there is somewhat of a judgment factor, particularly when you get into the Northern States Power case where you could have gone along pretty well up to one point, but when you add on something new that has not been designed, that changes the whole thing.

I think we all recognize that there are no easy answers. We are struggling with them, and, with your help, we hope to solve them a little better than we are doing.

Chairman ANDERSON. In view of the pressure we have on time, would you mind if we shift to contract activities and insert the balance of your statement?

Mr. GRAHAM. No, sir. I would be very happy to, sir.

Chairman ANDERSON. Very well.

Mr. GRAHAM. The complexities of the problem of site criteria, and its interrelation with problems of design, containment, and operation, are becoming increasingly evident, and our study of criteria on all the major aspects of reactor safety has recently been expanded. With the cooperation of the Advisory Committee on Reactor Safeguards, the Commission established a special working group, in which experts from industrial organizations are participating, to examine the present status and future course in the program to develop detailed criteria and other tools useful in the safety evaluation of reactor projects.

Chairman ANDERSON. We will go to section 170.

Mr. GRAHAM. 170. During 1959 the contract activity of the Commission exceeded in terms of dollar volume of contract commitments every previous year except the peak year of facility expansion that followed the Korean emergency.

171. In recognition of the important role of its contract program, the Commission late in 1959 established as part of the General Manager's Office, the Office of Contract Policy. The director of this new office is John R. Moore, who brings to this post 9 years' experience at our Oak Ridge Operations Office where he served both as principal contract negotiator and as chairman of the Contractor Selection Board.

172. The Office of Contract Policy consolidates review and formulation of contract policy. We look to this office to provide a focal point for assistance to the General Manager, headquarters and field staff on major contract policy matters, such as contractor selection and fixed-fee schedules. Establishment of this office will not impair the authority of program divisions and managers of operations to negotiate and administer contracts.

173. Additional authority has been decentralized to the field in the reactor development program. Technical and contract administration responsibilities have been assigned to specific offices by reactor concept. For example, the Oak Ridge Operations Office has been assigned administration of the gas-cooled reactor program as a primary responsibility. A related effort is to concentrate in a designated office responsibility for handling business matters relating to all Commission contractual activities with each major contractor.

174. Increased use is being made of master or task-type contracts. Under such contracts, one set of general terms or conditions applies

uniformly to all Commission work placed with a company. Greater administrative efficiency is expected to result from these changes.

175. Further, the Commission modified its policies to permit managers of operations to submit directly to the Comptroller General of the United States any cases arising from mistakes in bids prior to award. We have modified our policies to permit managers of operations, as of February 11, 1960, without referral to headquarters, to make awards to small business concerns or contractors who will perform work in surplus labor areas at a differential of up to 12 percent over a low foreign bid.

176. During the year the Commission worked out with the Administrator of General Services the relationship of the recently issued Federal procurement regulations to the procurement authority contained in the Atomic Energy Act. It has been agreed that these regulations do not impair any authority contained in the Atomic Energy Act. The Commission will follow the regulations in all areas except those in which the special nature of our programs require otherwise. In addition, essentially all AEC procurement policy will be published in the Federal Register.

177. As reported to the Joint Committee during the last session, appeals arising under "disputes" articles of contracts now are heard by a single hearing examiner instead of by the Advisory Board of Contract Appeals. Our experience indicates that the delays which have occurred have resulted primarily from the request of parties, not from the procedure. The time required for rendering a decision, after submission of briefs, has been cut to approximately 4 to 6 weeks from the average of 18 months under the Advisory Board system.

178. The Commission, on December 29, 1959, published in the Federal Register a complete revision of its rules of procedure governing contract appeals. This revision constitutes a practical formalization of the rules to insure that the issues of dispute are clearly defined, and to insure that all relevant evidence is made available. The latter is accomplished by providing for the use of subpenas and, where necessary, the use of the discovery process, such as taking of prehearing depositions.

179. Indemnifications under the Price-Anderson Act now have been extended to all major AEC installations where a substantial nuclear hazard is present. Commission licensees are steadily qualifying for coverage under the act under the procedures that have been established. We have now extended coverage to common rail carriers hauling Commission materials. A detailed report on this subject will be submitted to this committee by April 1, as required by the Price-Anderson Act.

Mr. RAMEY. On your provision on contract appeals, it might be pointed out again you have the same hearing examiner, then, that can decide the same contract appeal. Again taking PRDC, if you had a contract argument, he would be the same fellow who decides the regulatory case.

You have a sort of classic example of mixtures of regulatory and proprietary activities.

I think a hearing-examiner procedure might be desirable to expedite contract appeals, but there is question as to whether it ought to be the same fellow or the same line of authority.

Mr. GRAHAM. Mr. Ramey, I would be the first to concede that you are an expert in this field on the AEC, and, if I may say so, I think Mr. Olson, who has had experience with the Navy, and in private life. Both of you are certainly well qualified to talk on this, and, if I may turn the microphone over to him, I am going to ask him to answer your question.

Mr. OLSON. I think, Mr. Ramey, that time will take care of the problem you are addressing yourself to, because the calendar of cases is building up on both sides of the fence, contract and regulatory matters. It will probably be such as to require a second hearing examiner in the very near future.

Mr. RAMEY. That would certainly help to take care of it.

Again, as I say, the principles you apply in regulatory matters are supposed to be very different than those that you apply on contracts. The contract animal is a different kind of animal than the regulatory.

Mr. OLSON. I view this a little differently, Mr. Ramey, although I conceded there is merit to the point you make.

I think that a good judge in a divorce case might also be a good judge in a tort case. I think if a man has the proper judicial approach in hearing the evidence, and makes sure that the record supports the findings, he will do well in both cases.

I would say, along the line of your suggestion, there is a great deal of expertise in the contract field, and we might look to that field when adding the second examiner.

Chairman ANDERSON. We are going to have to adjourn in the next few minutes.

Mr. GRAHAM. Thank you, sir.

We are practically finished.

180. Abroad, the Organization for European Cooperation, the International Atomic Eneregy Agency, and the European Atomic Energy Community, all are working toward conventions to cover public liability.

181. I mentioned last year that the Commission and the Department of Defense were seeking closer agreement on cost-reimbursement principles in view of the large number of contractors holding cost-type contracts with both agencies.

182. We are in general agreement, but there are three specific areas in which our policies will continue to be somewhat different. These are (1) advertising, (2) bidding expenses, and (3) bonuses of a profit-sharing nature. Our basic reasons continuing to hold these costs unallowable is that they are not, in our judgment, related closely enough to the performance of the contract work.

Chairman ANDERSON. May I say to you, Mr. Graham, that I think we ought to compliment the Commission on that. Some of us who steadily read advertisements about how the referee lifts one player up to make a basket are delighted to know that the Commission is not spending money on such trash.

Mr. GRAHAM. Thank you, sir.

183. The Commission has modified its policy on depreciation to make allowable amounts recognized as deductible for tax purposes by the 1954 Internal Revenue Code. Treatment of privately financed basic research as an allowable cost is being given further study by the Commission.

Representative HOLIFIELD. What do you mean, allowing privately financed research as an allowable cost? Do you mean on the specific job under contract?

Mr. FLOBERG. This refers to an item of overhead.

Representative HOLIFIELD. You mean applicable to a particular contract?

Mr. FLOBERG. It would be part of the overhead. That is the question. A contract that is made with an operator that is on a cost basis includes all the direct allowable costs, direct labor, direct materials, and any other directly calculated expense, plus an item of overhead.

The question is what should go into the item of overhead. There are a great many things on which there is no problem. One of the questions is the general research that this company does, either in the field or related to the field, that is not under direct contract with the Commission but is an expense of doing business.

The question is what should or should not be an item of overhead, the same as the president's salary.

Representative HOLIFIELD. You mean if General Motors has a certain amount of privately financed research, that they are allowed to take a certain percentage of that and place it as an allowable load on the AEC contract?

Mr. FLOBERG. That is the question. If it is research on an automobile or product line of that sort, there would be no question about it. The question is when it is research on a direct or reasonably directly related line. This comes up in Pentagon contracts all the time, and it is beginning to come up in ours, too. That is precisely what the question is. Suppose it were General Motors Co., if you want to use that particular company.

Representative HOLIFIELD. I just picked it out of the air.

Mr. FLOBERG. It is good enough for me.

If we had a cost-type contract with them on some nuclear effort, and they were doing some other general research which was improving their general capability to perform this contract with us, or to expand the industry as we are under statutory obligation to do, to develop the industry, the question is whether that is an allowable cost of contract as an overhead item. That is, some percentage based on a dollar proportion or some other proportion, as the Pentagon.

Representative HOLIFIELD. What kind of Pandora's box does that open?

Mr. FLOBERG. No, I don't think so. I think it is handled pretty well in the Pentagon.

We have had some arguments about this in the Commission. I don't think it opens Pandora's boxes. It increases the general capability of industry to perform contracts for the agency in question.

Representative HOLIFIELD. When you contract with an agency you contract with them on their ability to do a job, and they are given a certain specified figure of profit. Are you going to go back and pay them for going to school and obtaining that ability? Is that the point?

Mr. FLOBERG. No.

Representative HOLIFIELD. In the first place, if they contract with you to render a service, one of the qualifications is that they are capable of doing the job.

Mr. FLOBERG. Yes.

Representative HOLIFIELD. So you give them a certain percentage of profit on that job.

Under this situation, as I see it, you then pay them because they have some know-how and they are capable of doing the job. You pay them in addition to the 6 percent profit, or whatever it is.

Mr. FLOBERG. Whatever the profit margin is, yes.

There are two sides to this, and I am arguing with you because you take the one side, and I will take the other. In fact, I will take it either side, as far as I am concerned.

Representative HOLIFIELD. I am not averse to doing the same thing.

Mr. FLOBERG. What you are saying is that a company that has the ambition, initiative and the capability of conducting independent research should be required to forfeit its profit in order to do that research.

Representative HOLIFIELD. That is contained in their bidding on the contract, or in their selection for the contract.

Mr. FLOBERG. That is the question.

Representative HOLIFIELD. That is one of the qualifications.

Mr. FLOBERG. That is one of the questions, whether their efforts to improve their capability to bid on this, by doing independent research, should be allowed just as an overhead item; that is, some proportion should be allowed as the cost of the contract.

Representative HOLIFIELD. I am glad for those last words, and I hope you will give it further study.

Chairman ANDERSON. Has thus far the answer been no when they asked for it?

Mr. FLOBERG. Up to now that is a correct statement. Generally speaking, the answer is that it has not been allowed as an item of overhead.

Representative HOLIFIELD. The Defense Department contracts have built half the defense plants in this country by the loopholes they have in them. We have been trying to hold the Commission on a pure basis.

Chairman ANDERSON. Have we finished discussing the small business section?

Mr. GRAHAM. 184. We are continuing our vigorous support of our established policy that a fair proportion of total purchases and contracts for Commission programs shall be procured from small business concerns.

185. Opportunity for the small business participation in prime contracts is not great since an extremely large dollar volume of these commitments is for the management and operation of Commission-owned production facilities and laboratories. Because of the magnitude of these operations, small business is not able to participate to a significant extent.

186. However, our prime contractors work actively to use small business for subcontracting in various ways. Typical of the methods are:

1. Publicizing and explaining purchase requirements at industrial opportunity meetings sponsored by the Small Business Administration and others.

2. Grouping of items in invitations to bid as to both category and quantity to afford small business maximum opportunity to compete, and

3. Working with the Small Business Administration to assure inclusion on bidders' lists of a maximum number of qualified small business firms.

187. Small business received an increased share of the total dollar value of Commission subcontract awards during the fiscal year ended June 30, 1959, totaling $220.8 million or 41.6 percent of $530.3 million total subcontract awards. By comparison, the small business share the previous 12 months was 39.3 percent, and for the 9-year period, 1951–59, the average share was 38.7 percent. At the prime contract level, the small business share increased 18 percent. Total prime contract awards to small business amounted to $144.5 million for fiscal 1959, compared with $102.8 million during 1958, and an average of $78.5 million for the 9-year period, 1951–59.

188. A number of amendments to the Atomic Energy Act affecting patents in the atomic energy field were proposed at the last session of the Congress. Congress extended section 153 of the Atomic Energy Act, permitting compulsory licensing of patent applications filed up to and including September 1, 1964. The Commission's conclusions and recommendations concerning the pending amendments, resulting from a review of its patent policies were presented to this committee in April 1959.

189. We have recently had the experience of a large company in the heat exchanger business refusing to continue on a job for us at Argonne National Laboratory. They stated that the Commission's strict construction of section 152 pertaining to patent rights on work done "in connection with" any contract with the Commission was burdensome to the point that they could not afford to do the job. The pending amendments would eliminate this type of problem.

Representative HOLIFIELD. I have one question to ask.

Did you find another company that was willing to do the job and willing to suffer this terrible burden, or does the job at this point remain undone because of it?

Mr. LUEDECKE. This is a very recent occurrence, Mr. Holifield, and we have not yet. However, this problem is involved in most of our contracts.

Representative HOLIFIELD. As a matter of fact, notwithstanding the patent provisions of the Atomic Energy Act, you have had no dearth of applicants for contracts on different projects?

Mr. LUEDECKE. No, sir; I would not call it a dearth of contractors. I think there are instances, though, when companies would otherwise have been interested who were not.

Representative HOLIFIELD. There is no doubt about that. If you double your price, you will probably get more companies interested.

Mr. LUEDECKE. I can't say there was a dearth of them, no, sir.

Representative HOLIFIELD. You have always had people perfectly willing to do business and accept your money, haven't you?

Mr. LUEDECKE. Yes, sir; I think I can answer to that.

Representative HOLIFIELD. There is a drive in the Space Committee now to change the patent provisions over there which were somewhat patterned after the patent provisions in the Atomic Energy Act.

They are scaring the members over there by saying, "if you don't remove the patent provisions we won't get anybody to do this space research and development."

I think they have them all scared over there that, if they don't take that section out, they won't have any contractors bidding on the contracts. I told them that the experience of the Atomic Energy Commission had not been one of having a dearth of contractors because of patent provisions.

Mr. GRAHAM. May Mr. Olson make a comment on this?

Representative HOLIFIELD. By the way, what was the name of this company that didn't want any business of you folks?

Mr. OLSON. It was Babcock & Wilcox.

I want to be sure we understand the exact issue here before war is declared on Babcock & Wilcox.

All they are objecting to is the phrase "in connection with." They were not objecting to our taking title to patents which developed under the contract. It was the phrase "in connection with."

We recommended the deletion of that phrase to the JCAE last year as being in excess of what we thought was required.

This does not purport to change the basic policy, Mr. Holifield, of the AEC getting the patents which are developed under the contract. It is the breadth of the language "in connection with."

I think Mr. Ramey is very familiar with this particular point.

Chairman ANDERSON. Sometimes you have to have breadth to be sure you cover the whole subject.

Mr. OLSON. Mr. Chairman, this has all the breadth that can be conceived. This is pretty broad, and it does shift the burden of proof in the event that there is any doubt.

We have a short time within which we must advise the Commissioner of Patents that we are going to take title and will investigate later. That shifts the burden of proof. To someone who is doing work in their regular line of business, I think there is a good argument that can be made that this "in connection with" is too broad and should be stricken from 152.

I firmly believe that the language "patents developed under the contract" is amply broad enough to protect the policy that this committee espouses.

Mr. RAMEY. As I recall, that language may have been derived originally from the Commission contracts.

Mr. OLSON. That may well be. As a matter of fact, a very good legal argument can be made that the language, even as written in the statute, is a procedural rather than the substantive part of the statute.

Mr. GRAHAM. Mr. Chairman, could Mr. Olson comment on the next item, on 190.

Mr. OLSON. With respect to background rights, we recently had a meeting with representatives of industry, a group of 15 or 20 selected representatives from industry, and they protested with respect to what they called the overreaching of our background policy.

We feel that if there is a need for the background rights that we must get them. We do agree that we should not ask for background data just because we want it. We must have a need for it because this has been developed with private funds.

Chairman ANDERSON. Are they just talking about data or background rights to patents?

Mr. OLSON. Background rights.

Chairman ANDERSON. Does this have anything to do with the Stanford accelerator and Varian Associates?

Mr. OLSON. It may very well come into that, yes, sir. That is a case where I think there is a need.

Chairman ANDERSON. They are asking for $107 million.

Mr. OLSON. I would feel that we might very well have a need for background rights in that particular case. I think that industry does have a problem here. I view it as a bargaining proposition, if we have a need for their background data.

Chairman ANDERSON. Data and rights are two different things.

Mr. OLSON. Data and rights are both involved here.

Chairman ANDERSON. They are? If we ask them for their background data we don't acquire any background rights, do we?

Mr. OLSON. If their background know-how is made available I am afraid it no longer becomes something of peculiar value to them. It is a business—confidential asset of theirs.

Chairman ANDERSON. I thought that patented processes were available. People could find out what was in the patent but could not use it. This says in acquiring rights in private background patents. That is quite a bit different than acquiring the data, isn't it?

Mr. OLSON. The two things always come up together, Mr. Anderson.

Let me confine it to background rights. If the circumstances are such that we are going to spend a great deal of money to improve a background right in which they have spent very little, it would seem that we should get complete background rights. On the other hand, if we spend very little to improve, and they have spent a great deal, or have a valuable patent, it might be that we should pay royalties to use their patents.

Mr. RAMEY. This is not a problem of the law or the statute, is it? It is just that AEC has a long tradition of hard bargaining with industry.

Mr. OLSON. That is right.

We simply wanted to indicate that this problem was recently under consideration.

Representative HOLIFIELD. In 190 you said:

> We also recognize that background rights to patents acquired at private expense must not be taken from the private owner without some form of compensation. * * *

As I understand it, you have all the procedures set forth in the Atomic Energy Act to compensate anyone for anything which they have acquired of their own right but which might be peculiarly necessary for atomic energy use.

Mr. OLSON. That is right.

Representative HOLIFIELD. Is that what you are talking about?

Mr. OLSON. We don't pay royalties in most cases because we feel that they have an interest in taking the contract, and get collateral benefits.

Representative HOLIFIELD. If they bid on a contract and they bring to it their background knowledge, to the contract, do you mean to say that they want to charge, in addition to their profits, royalties

for anything that they use which they have patented in their field of competence?

Mr. OLSON. Not with respect to the item they are building for us, but we want to get sufficient rights so we can build additional copies. We want a royalty-free, nonexclusive right so we can go ahead and build additional copies of the same thing.

Representative HOLIFIELD. In other words, you want to acquire from them these rights which they have developed at their own expense, and then transfer them to other companies in the future, possibly.

Mr. OLSON. We may want to, yes.

Representative HOLIFIELD. Without compensation?

Mr. OLSON. If we were going to transfer them to other parties, ordinarily we want to make sure that we have a right to make a carbon copy for governmental purposes at least, and that might include the EURATOM purpose or mutual defense purposes. I am not aware of any case where we wanted to transfer the background rights without royalties to other parties. Mr. Anderson, AEC Patent Counsel, will answer.

Mr. ANDERSON. That is correct. In certain instances where we have requested a background license, there has been an agreement to grant royalty-bearing licenses to private parties who are interested in acquiring them. We have requested, however, that the Government get Government-free licenses on background inventions where the situation is one where the contractor may have a concept or may have filed a patent application but done little or no work and we spend AEC money to develop or perfect a device.

Representative HOLIFIELD. That is a different problem. Now you are talking about taking Government money and developing a patent for them.

Mr. ANDERSON. This is what you pick up when you get to background patent rights, those things that may be partly developed. There may also be something that they have already developed which AEC is going to improve.

In connection with the improvement and the adaptation of such an item for our uses, we may ask for a background license, limited to governmental purposes, or in special instances limited for a specific reactor or for a particular use, depending on the circumstances. It is for these reasons, among others, that we feel our policy should be flexible. The AEC manual therefore has a suggested provision.

A number of companies have objected to the fact that some of our negotiators may have been a little overbearing in asking for background license rights of broad scope when only one of limited scope was required, or maybe they have asked for one where no background right was required. The background provision is a clause subject to negotiation.

Chairman ANDERSON. Is it not a good policy to ask for quite a good bit to protect yourself under those circumstances, rather than to get hooked?

Mr. GRAHAM. Yes.

Mr. OLSON. Industry assures us that we have asked for everything that we need.

Representative HOLIFIELD. I am not in favor of taking patents from any company that has developed them with their own money,

and defrauding them of their rights, or confiscating their rights without compensation. But certainly, in the field of research and development, where Government moneys are used, you certainly establish rights for the Federal Government in that instance, which I think ought to be fairly considered in arriving at any contract.

Mr. OLSON. That is right. You have to look at every case to see what is fair. We will spend a little bit on a patent on which they have spent a great deal of money, and we should not demand rights without royalty payments.

Representative HOLIFIELD. That is right.

Chairman ANDERSON. Do you have to have legislation to deal fairly?

Mr. OLSON. No, sir.

Chairman ANDERSON. Then what are you talking about? He said they have pending amendments.

Mr. OLSON. This is with respect to an amendment of section 152 that we asked for last year and does not relate in any way to the background problem.

Chairman ANDERSON. Very well.

Mr. GRAHAM. Turning now to the last portion—fuel supply:

192. The Commission's receipts of uranium concentrates from all sources under its various domestic and foreign arrangements, as projected over the next 3 years, exceed the Nation's estimated requirements to meet its weapons and power programs. The Commission has continued its efforts to bring supplies closer to a balance with requirements by arranging for deferred delivery of domestic and Canadian concentrates.

193. The Commission's contracts provide for a firm schedule of deliveries within the time period covered by each contract. We are not reneging on those contracts. In the United States we are negotiating with producers to arrange postponement to the 1962–66 period of portions of deliveries scheduled for 1960–62. In some cases this involved deferrals under contracts that already extend to 1966; in other cases, deferrals are being arranged in negotiated renewals of contracts that would expire at a date earlier than 1966. These negotiations do not reduce the quantities of ore the mills buy from independent ore producers, but result in limiting production in the pre-1962 period of ores owned or controlled by the milling companies.

194. The Canadian contracts also call for a firm schedule of deliveries. They are due to expire in 1962 and 1963, and provide options under which the Commission may renew the contracts for additional periods of time. We have notified the Canadian Government that we would not exercise any of these options. The Commission and the Canadian Government reached an agreement which permits postponing some deliveries presently scheduled before 1962 or 1963 to a period beyond the expiration date of existing contracts, that is, in the 1962–66 period. The total to be delivered over the longer period will not exceed the amount scheduled under the original contracts.

195. In keeping with its limited domestic expansion program announced April 2, 1958, of providing an ore market in certain areas which had reserves but had inadequate market, agreements were reached in 1959 for an additional 1,560 tons per day capacity for the central Wyoming area and the installation of a 200-ton-per-day

mill in the Colorado Front Range. Further additions in these areas are not presently contemplated.

196. No agreements have been reached for southeast Texas, Nevada, and North Dakota-South Dakota lignite areas.

197. Other aspects of the Commission's raw material program are covered in detail in the Commission's annual report.

CONCLUSION

198. Mr. Chairman, members of the committee, this concludes the Atomic Energy Commission's statement. Our written submission supplements our testimony.

199. We will be pleased to present any additional information the committee may wish. My colleagues on the Commission, the General Manager, and our principal staff, are here to assist you.

Chairman ANDERSON. I do not see any member of the committee that has a question at this time.

Mr. GRAHAM. We thank you very kindly for a very interesting and profitable, from my standpoint, and instructive session.

Chairman ANDERSON. Thank you.

I want to assure you that I appreciate the testimony of all the members of the Commission and the members of the Commission staff who have been here.

The hearing will continue tomorrow afternoon at 2 o'clock with industry representatives from General Electric, Tracerlab, Inc., General Dynamics, Alco Products, and Radiation Dynamics, Inc.

We will adjourn until 2 o'clock tomorrow.

(The full statement of the Atomic Energy Commission referred to on p. 3, follows:)

TESTIMONY BY CHAIRMAN JOHN A. MCCONE, U.S. ATOMIC ENERGY COMMISSION, BEFORE JOINT COMMITTEE ON ATOMIC ENERGY, U.S. CONGRESS, AT HEARINGS PURSUANT TO SECTION 202, ATOMIC ENERGY ACT OF 1954, FEBRUARY 16, 1960

At this year's hearings before the Joint Committee pursuant to section 202 of the Atomic Energy Act, the Commission's testimony concerning the development, growth, and state of the atomic energy industry will again consist of two parts—written and oral.

To avoid repetition, we would like to present for reference the Commission's Annual Report to Congress for 1959. This report describes the progress of the industry during 1959, related Commission programs, and other major activities in which members of the Committee have expressed special interest. The annual report incorporates a special report on "Management of Radioactive Wastes," and a summary of what we know and are seeking to learn about fallout from weapons tests. We have also submitted for reference a special report called "Radioisotopes in Science and Industry."

Today I will present first, the power reactor program and then review programs on which Senator Anderson in his letter of January 6, 1960, has asked us to comment. I should like to begin reading portions of part IV of the "Civilian Power Reactor Program."

CIVILIAN POWER REACTOR PROGRAM—PART IV. PLANS FOR DEVELOPMENT

INTRODUCTION

1. The first phase of a continuing study to develop long-range plans for the civilian power reactor program has been completed. Most of the information developed to date as part of this study is included in four reports. These reports, listed below, will be published and given public distribution.

(*a*) "Civilian Power Reactor Program—Part 1. Summary Current Status of Reactor Concepts." [1]

(*b*) "Civilian Power Reactor Program—Part II. Economic Potential and Development Program."

(*c*) "Civilian Power Reactor Program—Part III. Technical Status." [1]

(*d*) "Civilian Power Reactor Program—Part IV. Plans for Development."

These reports represent the first phase of a continuing study to develop long-range plans for the civilian power reactor program. Additional reports on the results of the continuing study will be published as appropriate.

2. In developing the program plans presented in the current report, primary attention has been given to the technological development required to achieve economically competitive nuclear power. Consequently, the development of prototypes for large central station powerplants figures prominently in the program. This should not be construed as indicating a diminution of Commission interest in, or support of a small power reactor program directed to achieving economically competitive nuclear power in plant sizes below 50 mwe. (electrical megawatts). A number of the reactors presently being built or planned will contribute to attaining this objective. As more information becomes available and is evaluated concerning these and other reactors, including military programs, additional prototypes of small power reactors will be considered for construction.

3. Our current program follows the orderly three-phase sequence for the development of individual reactor concepts as described to this Committee in our testimony last year. This sequence in general contemplates construction first of reactor experiments or experimental reactors, followed by prototypes and then by plants of commercial proportions. It is the opinion of the Commission that the reactor experiments should be built and operated by the Commission. Prototypes should be built and operated by publicly or privately owned utilities independently or in cooperation with the Commission; alternatively, prototypes could be built and operated by the Commission. Industry should assume the primary responsibility for large commercial size nuclear power stations; however, the Commission will consider possible assistance on initial plants in various concepts useful for demonstration purposes. We believe it important that the large plants and, as far as possible the prototypes as well, be integrated into utility power grids in order to demonstrate load factors, dependability, and other operating characteristics which affect the economics of the plants.

4. Experimental and prototype reactors will be constructed as a part of the Commission's program when the plans for experimental work indicate that the technical or economic information and operating experience to be derived from the facility is essential to the Commission, or to the power industry, in the efforts to reduce the cost of nuclear power. In the development, construction, and operation of prototype and full size power producing reactors, the Commission will work cooperatively with reactor manufacturers and with publicly and privately owned utilities.

5. Any arrangements whereby the Commission provides significant financial support will include provisions to assure that an experimental testing program can be carried out with the reactor during its early operation. Testing programs will vary with each project. When power generation is involved, this fact will be taken into account when establishing the testing program.

6. We plan a continuing evaluation and reappraisal of our program. New ideas and new technologies, including those developed in other countries will be reflected in this continuing evaluation. Periodic program reviews will consider carefully the relative merits of various lines of development looking toward reduction or elimination of some efforts, and initiation of, or increases in others. Should information indicate that a concept is not useful in meeting our objectives, the concept would be dropped.

Program Objectives

7. In previous reports and testimony before the Joint Committee on Atomic Energy (February 1959 Hearings on the Development, Growth, and State of the Atomic Energy Industry), the Commission set forth the following five objectives for its civilian power program:

[1] See app. A for volumes.

First: Reduce the cost of nuclear power to levels competitive with power from fossil fuels in high energy cost areas of this country within 10 years.

Second: Assist friendly nations now having high energy costs to achieve competitive levels in about 5 years. This assistance is to be extended mainly through clearly defined programs of cooperation.

Third: Support a continuing long-range program to further reduce the cost of nuclear power in order to increase the economic benefits and extend these benefits to wider areas.

Fourth: Maintain the U.S. position of leadership in the technology of nuclear power for civilian use.

Fifth: Develop breeder type reactors to make full use of the nuclear energy latent in both uranium and thorium, recognizing that U–235 alone may not be sufficiently plentiful to meet our needs over the long range.

8. The first and third objectives are directly applicable to the development of central station powerplants, and they have been used as the principal factors in establishing that part of the program outlined herein which deals with these plants.

9. In order to permit a more exact statement of the initial goal of the program, the first objective has been further defined as follows:

(*a*) The 10-year period is measured from 1958, when the objective was first stated. This establishes 1968 as the target date for achieving competitive power in high-cost energy areas.

(*b*) It is considered that competitive nuclear power will have been achieved when utility executives can make a decision to build nuclear stations on the basis of economic considerations over the lift of the reactor.

(*c*) High-cost energy areas are considered to be those areas where fossil fuels presently cost 35 cents per million B.t.u. or higher.[2]

10. No attempt has been made to assign a quantitative definition to the third objective either with regard to time or to the extent of the "wider areas." This objective is the basis for the longer range development program aimed at lowering the cost of nuclear power to a point where it is competitive with fossil power in ever-increasing areas of this country.

11. The other three objectives are more general in nature. With the passage of time and events, conditions relating to two of the objectives have changed substantially.

(*a*) The second objective relates to the achievement of economic nuclear power abroad. When this objective was first stated, it appeared that it could be achieved first in Western Europe in about 5 years. In the last 2 years the increased availability of fossil fuels and the drop in their shipping costs have brought the timetable of achieving economic nuclear power in Europe closer to that of the United States.

(*b*) The fifth objective recognizes the long-term importance of the development of nuclear power systems which can use a major fraction of the uranium and thorium available. At the present time it is not possible to make an accurate prediction of the time when uranium shortages and rising costs associated with such shortages will make the more efficient use of source material a vital factor. However, the ultimate importance of conservation of nuclear fuel dictates a long-range program to develop the breeding potential inherent in both the uranium 238-plutonium and the thorium uranium 233 fuel cycle.

There has been no change in the fourth objective. The Commission has endeavored and will continue to strive to maintain the United States in a position of leadership in atomic energy use for civilian purposes.

Specific Programs

12. Necessary congressional authorization will, of course, be sought before proceeding with new projects considered in the following concept-by-concept review.

I. Light Water Cooled Reactors

13. There is a relatively high probability that light water-cooled reactors in the reasonably near future can achieve competitive power in the high fuel cost

[2] Conventional power costs in these areas are estimated to be about 7 mills per kilowatt-hour for a 300 mwe. single unit fossil fuel station using fuel costing 35 cents per million B.t.u. (200 p.s.i.a. 1050° initial/1000° F. reheat, 1½ inches of mercury back pressure), based on 1959 cost levels, no escalation, 80-percent capacity factor and 14-percent fixed charges.

areas of the United States where large single units are practical. In addition, water reactors also offer a longer range potential for being competitive in many other areas of the United States.

14. Over the next 4 or 5 years, Commission supported research and development work on water reactors will be aimed primarily at solutions of the problems of nuclear superheat, increased fuel life, decreased fuel costs, simplified fabrication techniques, fuel management, simplified and less costly containment methods and cheaper materials and methods of construction.

15. A major effort will be made to develop techniques for economically utilizing plutonium as a fuel material in water reactors.

16. The water cooled reactor program is described under three categories: Pressurized water, boiling water, and nuclear superheat.

A. *Pressurized Water Reactors*

17. The pressurized water reactor concept is technologically well advanced and is the concept with which we have had the most experience. This experience has demonstrated that pressurized water reactors are safe, dependable, and reasonably easy to control. Capital costs of a 30 mwe. plant of this type, as quoted recently by the manufacturers on a fixed-price basis, when taken in conjunction with fuel guarantees reported to the Commission by utilities and core manufacturers, indicate that the power produced from such a plant constructed now should be competitive over its life in high fuel cost areas of the United States where a plant of this size can be used.

Plans for use of existing or authorized facilities

18. *Domestic civilian power program.*—(*a*) The reactor at the Shippingport, Pa., atomic power station will be modified to raise its power to 150 mwe. equivalent. It will continue to be operated to demonstrate the life potential of the present rod-type blanket elements as well as of the newly developed high-power density flat oxide feed and blanket elements. The present core will then be replaced by the newly developed 150 mwe., high power density flat plate oxide seed and blanket core. The reactor plant and its associated facilities will be used also to further demonstrate the technical and economic feasibility of the seed and blanket concept. The developmental cores to be installed at Shippingport upon completion of the PWR Core 2 lifetime will depend on the results obtained in the development, testing, and operation of PWR Core 2. For example, consideration will be given to: the installation of still higher power cores if feasible and/or the utilization of other fuel materials such as plutonium, uranium 233, and thorium in this developmental reactor facility.

(*b*) The Yankee Atomic Electric Co. plant at Rowe, Mass., is scheduled for criticality in 1960. It will operate initially at 110 mwe. Among the important new features to be tested in the plant are stainless-steel clad slightly enriched uranium dioxide fuel elements and solution poison for shutdown control. Statistically important utility operating and maintenance experience will be gained from this relatively large-scale reactor operating principally as a power producer.

(*c*) Two pressurized water reactors are being built by private industry without substantial Government assistance: A 151 mwe. reactor is being built by the Consolidated Edison Co. of New York at its Indian Point, N.Y., plant which, with conventional superheat, will product 255 mwe. It is scheduled to go critical in 1961. The Saxton Nuclear Experimental Corp.'s 5-mwe. reactor experiment will furnish steam to the Pennsylvania Electric Co.'s plant at Liberty, Pa., and is scheduled to go critical in 1962. These plants will add much information to the technology of pressurized water plants. The Indian Point plant will provide important operating data for large water-cooled reactor systems and technical data on the use of thorium U^{235} fuel mixtures.

(*d*) A 40-thermal-megawatt process heat reactor is to be built in California in cooperation with the Department of the Interior. It is scheduled to go critical in 1962. This reactor will explore the economics of reactors for production of low-temperature, low-pressure steam for use by the process industries.

(*e*) A 16-mwe. prototype with 6-mwe. conventional superheat will be built primarily to demonstrate the economics of pressurized water reactors as small power reactors. This reactor will provide operating information important to the design of large pressurized water reactors. The feasibility of bulk boiling in pressurized water reactors will also be demonstrated in this reactor. Five proposals have been received for this reactor to be built under a second-round-type authority. The target date for criticality is 1962.

19. *Military and maritime contributions.*—(*a*) The Navy will put into operation a large number of nuclear-powered submarines and surface ships in the next few years. The supporting research and development work for these reactors has contributed and will continue to contribute significant data to the civilian reactor program. The natural circulation prototype reactor to be built at the National Reactor Testing Station (NRTS) may be of particular interest to the small power reactor program.

(*b*) The Army reactor program will develop much information of value to the civilian reactor program. Civilian reactor development will benefit from the standardization of components and materials which will be a natural outgrowth of the Army program. The studies on use of reactors in remote military locations will be of particular importance in developing safe, reliable small nuclear power plants for use under a variety of climatic conditions in all parts of the world.

(*c*) The pressurized water reactor installed aboard the NS *Savannah* should contribute important technology to the civilian reactor program, and in particular to the future of maritime nuclear propulsion.

20. In addition to the work being done in this country, design, construction, and operating experience will also be obtained from Selni in Italy and the Mol plant in Belgium.

Future plans

21. It is probable that at least one additional pressurized water prototype will be justified by research and development results and operating experience. Such a prototype would be designed to demonstrate improved technology growing out of the operation of the Shippingport, Yankee, and Indian Point plants, and out of development and design of the other reactors listed previously. This prototype, if justified by developments and analysis, would incorporate improvements in plant design, construction, containment, and components which would lead to lower power costs. Design of such a plant could be begun in 1962, with construction starting in 1963 or 1964.

22. If the development work which is being initiated this year on the spectral shift[3] variation of pressurized water systems is successful, and the idea still appears promising, construction of another prototype reactor, possibly 50–100 mwe., to demonstrate this technology and its economics also would be started in the early 1960's.

23. As has been discussed before, information submitted to the Commission by reactor manufacturers indicates that utility managements may be in a position to make decisions now to build large pressurized water plants in high fuel costs areas in which large plants are practical, basing their decision on economic considerations. The construction and operation of one or more such plants as a part of utility systems located in such areas would play a valuable role in the development of economic large central station nuclear power plants.

24. The studies which are currently being made with respect to the feasibility of reactor-generated power in remote locations together with the technical information developed in Army and Navy reactor programs may indicate the desirability of initiating in 1962 a small power reactor prototype (20 to 30 mwe.) at some installation which would offer a test of reliability under varying conditions.

B. *Boiling Water Reactor Program*

25. The technical feasibility of boiling water reactors has been successfully demonstrated by the Borax experiments at the National Reactor Testing Station in Idaho, the experimental boiling water reactor at Argonne National Laboratory, and the Vallecitos boiling water reactor in California. Based on currently available information, there is every reason to believe that the large Dresden plant now in its startup phase, the Humboldt Bay plant, and the Rural Cooperative Power Association Elk River plant, all using boiling water reactors of varying size and design, will operate successfully and will furnish valuable information.

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[3] The spectral shift reactor is one in which heavy water is added to the light water coolant. Initially a high concentration (75 to 80 percent) of heavy water is used. As the fuel burns, the concentration of heavy water is reduced (to about 25 percent) in order to decrease the neutron diffusion rate which increases reactivity and extends fuel life.

Plans for existing and authorized facilities

26. *Domestic civilian power program.*—(*a*) The modifications now underway on the experimental boiling water reactor which will raise its power to 100 mwt. will be completed and the experimental program of study of the behavior of the boiling water system will be resumed. The modified reactor will be used initially to demonstrate the stability of a boiling reactor at higher power density, and it will serve as a boiling water fuel element test facility. Plutonium fuel development and water chemistry will be studied in this reactor.

(*b*) The 16-mwe. indirect-cycle boiling water with 6 mwe. conventional superheat Elk River plant is scheduled for criticality in 1960. This reactor is primarily of interest in the small powerplant program. Experience gained from it will also aid in the evaluation of certain variations in boiling water reactor design of possible interest to larger plants. These variations include use of mixed thorium oxide and uranium oxide fuels, and of an intermediate heat exchanger in a boiling system.

(*c*) Three boiling water reactors have been built, or are being built, by private industry without substantial Government assistance. General Electric's 20 mwt. (5 mwe.) Vallecitos boiling water reactor near Pleasanton, Calif., is being modified. Commonwealth Edison Co.'s 180 mwe. Dresden nuclear power station at Morris, Ill., has gone critical, and the 48-mwe. Humboldt Bay (Calif.) reactor of the Pacific Gas & Electric Co. is scheduled to go critical in 1962. The experimental and operational date from these reactors will add much information on the technology of boiling water reactors, and the latter two will provide valuable statistical operation and maintenance data for water-cooled reactor systems. The programs of these reactors will supplement the work being carried out in plants built with Government support, and will be an important part of this country's overall program for the development of boiling water reactors.

(*d*) Construction of a 50–75 mwe. high-power-density boiling water prototype is planned to begin in 1960, with criticality scheduled for 1963. This plant will be designed and operated in such a way as to provide technical and economic information on operation at power densities of the order of 60 kilowatts per liter and at fuel lifetimes similar to those experienced at lower densities. Negotiations are currently underway between the Commission, the Consumers Power Co. of Michigan, and the General Electric Co. to develop a mutually satisfactory cooperative program for this reactor. Information from this program will be of value to both large and small power stations.

(*e*) A simplified 50 mwe. boiling water prototype reactor will be constructed to demonstrate design improvements which will reduce the size, complexity, and cost of boiling water reactors. Such features as improved control methods, simplified containment, elimination of high risers, and increased power output per unit of water flow will be incorporated in the design. Invitations have been issued for proposals from interested utilities. It is expected that construction will start in 1960 or early 1961. The target date for criticality is 1964. While this reactor will be primarily a prototype for future large reactors, the engineering improvements made will in general, be equally applicable to small reactors.

27. In addition, Italy will build the 150 mwe. Senn reactor. It will contribute experience in design, manufacturing, operating, and maintenance for a large boiling water reactor plant. Information developed will be available to the Commission and to industry through an exchange program.

Future plans

28. Aside from developments involving nuclear superheat which are described elsewhere in this report, most of the currently foreseen developments in boiling water technology probably will be demonstrated with reactors currently in operation, being built, or authorized. When operating experience is available from these reactors, in 1963 or 1964, it will be possible to determine what, if any, additional experimental or prototype reactors are needed to achieve competitive power in large boiling water reactors. Until such a determination is made, no further construction of large boiling water experimental or prototype reactors is contemplated by the Commission.

29. In the small reactor field, results from Elk River, Humboldt Bay, and the simplified reactor project discussed earlier may indicate in 1963 or 1964 the need to initiate construction of a small (20–30 mwe.) prototype.

30. As in the case of pressurized water reactors, we have been advised by a manufacturer that a 300 mwe. boiling water plant can be built now on a fixed price basis, with certain fuel cost guarantees, which may produce power

competitive with conventional power in certain high cost fuel areas of the United States. It is the Commission's opinion that the construction of one or more boiling water plants by utility companies in high cost areas where plants of this size may be practical would make a significant contribution to the development of economic power.

C. *Nuclear Superheat*

31. Nuclear superheat can be applied to both direct- and indirect-cycle boiling water reactors, and to indirect-cycle pressurized water reactors. In direct-cycle boiling water reactors, nuclear superheat may be integral. In indirect-cycle reactors, whether boiling or pressurized, what is essentially a separate steam-cooled reactor would be required to obtain nuclear superheat.

32. Nuclear superheat would make possible production of steam at temperatures and pressures used in modern conventional powerplants of high efficiency. Development work and design studies have been underway for some time, concentrating chiefly on the superheat fuel element. Data from these programs are applicable to both direct- and indirect-cycle reactors. Design studies and evaluations have been made on integral superheat systems, and soon will be initiated on separate superheat systems.

Plans for existing and authorized facilities

33. *Domestic civilian power program.*—(*a*) The fifth boiling reactor experiment (Borax 5) is under construction at the National Reactor Testing Station and is scheduled to become critical in March of 1961. The reactor will be operated initially with a limited number of test channels producing superheated steam and will be converted gradually into an integral nuclear superheat reactor. Flexibility designed into the system will permit investigations of nuclear stability problems associated with various fuel and coolant arrangements.

(*b*) The Northern States Power 62 mwe. plant near Sioux Falls, S. Dak., is under construction and is scheduled for criticality in 1962. This reactor will provide test and operating data on a high density, integral nuclear superheat core. Development work leading to reduction in the enrichment of fuel in the superheat section of the core will continue.

(*c*) A contract has been signed with the Puerto Rico Water Resources Authority for construction of a 16 mwe. boiling nuclear superheat reactor (Bonus). This reactor will provide information on the practicality of an integral nuclear superheat design for small reactors and will assist in the evaluation of nuclear superheat in large plants. The target date for criticality is early 1963.

Future plans

34. If the technical and economic information obtained from these projects confirms the prediction that nuclear superheat can substantially lower power costs in boiling water reactors, a 100 mwe. prototype would probably be required to exploit the full potential of the system. Such a prototype, if justified, probably would be initiated in 1963.

35. If the program outlined above is followed and it proves successful, it is anticipated that by 1968–69 sufficient technical and economic information will be available to permit utilities in certain areas of the country to decide on economic grounds to construct a large (300 mwe.) integral superheat plant.

II. ORGANIC COOLED REACTOR PROGRAM

36. There is relatively high probability that organic cooled reactors can achieve competitive power in high fuel cost areas of the United States by the middle 1960's and in the longer range over many other areas. Because of the encouraging experience in operation of the organic moderated reactor experiment and in other research and development work already done, because of the relative simplicity of the system, and because of the direct applicability of much of the technology developed in water reactor programs, it is believed that this concept can achieve its early potential with less research and development and construction of experimental and prototype plants than are required for other reactor concepts.

37. Organic-cooled reactors operate at higher temperatures and lower pressures than water reactors, and have no major corrosion problems. These characteristics make for low capital cost plants. However, high costs for replacing decomposed coolant are an economic disadvantage. Organic coolants also

have poor heat transfer characteristics and require fuel elements with extended surfaces and high conductivity cladding. Since a longer lived fuel must be developed, research and development work at present is primarily on aluminum-aluminum oxide claddings for uranium oxide and uranium alloy fuel materials. Research and development work also is directed toward lower organic makeup costs and improving organic fluid flow and heat transfer characteristics.

38. In the longer range, the research and development program will be directed toward utilizing plutonium recycle in organic reactors.

Plans for use of existing or authorized facilities

39. *Domestic civilian power program.*—(*a*) The 5- to 15-mwt. organic moderated reactor experiment (OMRE) at the National Reactor Testing Station is being modified to make it a more suitable test facility and to reduce its cost of operation. It will continue to be used as a fuel test facility, for determining coolant decomposition rates, and for conducting heat transfer and surface fouling tests.

(*b*) The 40-mwt. experimental organic cooled reactor (EOCR) is presently being designed, with construction scheduled to start this year at NRTS. It is scheduled to be critical in 1963. This facility will have more flexibility than the OMRE. It will allow an acceleration of the rate at which alternative fuels, coolants, moderators, and operating conditions can be investigated, and it will give greater assurance that improvements will be available for organic reactors that might be built in the future.

(*c*) The 11 mwe. organic-cooled and moderated reactor being built for the city of Piqua, Ohio, is scheduled for criticality in 1961. It is of primary importance as a prototype for small nuclear power plants, and it will make possible a reasonable analysis of the potential of the organic concept in this size. It will also provide operation data that can be extrapolated to larger plants.

(*d*) A 50 to 100 mwe. organic-cooled prototype is planned for construction. Its primary purpose will be to provide data on use of an improved fuel, such as aluminum cermet clad uranium dioxide. An invitation for proposals to build this reactor has been issued under the fiscal year 1960 authorization. Should no acceptable response be received to the invitation, and if research and development results continue to be favorable, the Commission proposes to start construction with funds included in the fiscal year 1961 appropriation request. The target date for criticality of this reactor is 1964. It is primarily a prototype for future large-scale power reactors, but the basic fuel element infomation which it will develop will be important for process heat and small power reactor systems.

Future plans

40. Assuming success in operation of the 50–100 mwe. prototype and in other research and development, it is anticipated that by 1965 or 1966 sufficient information will be available to permit a utility to decide, on economic grounds, to construct a 300 mwe. organic-cooled reactor in a high fuel cost area.

41. In the middle 1960's continuing research and development, if successful, should indicate further improvements possible in organic-cooled reactors. A 50–100 mwe. prototype may be justified to demonstrate these features.

III. SODIUM-COOLED REACTORS

42. Sodium-cooled reactors appear to have a high potential for achieving competitive power in large areas of the United States in the late 1960's or early 1970's.

43. Sodium has many attractive features as a reactor coolant. It is liquid at relatively low temperatures, has a very high boiling point, reasonably low neutron absorption cross section, and excellent heat transfer and heat transport qualities. These characteristics make possible very high steam cycle efficiencies. Because of the negligible pressure required for sodium systems, very large sized (500 mwe. and larger) reactors are practical. This is an advantage since unit power costs generally decline with increased plant size. The experimental breeder reactor No. 1, the sodium reactor experiment, and the submarine *Seawolf* and its prototype reactor have demonstrated that sodium-cooled reactors can be operated safely. However, there still are problems with fuel elements and components which must be solved before these systems can achieve their full potential.

44. Since liquid sodium is not in itself a moderator, systems which use this material as a coolant can operate over a wide neutron energy spectrum, depending upon the presence and characteristics of moderating material. In fast and possibly in epithermal systems, sodium-cooled reactors are capable of breeding. Sodium-cooled reactor systems can operate with uranium 238 plutonium fuel systems or with thorium-uranium 233 systems.

45. The Commission's program for sodium-cooled reactors is presented under two headings—"Fast reactors" and "Thermal reactors."

A. *Sodium-Cooled Fast Reactors*

46. Most of the technical and economic advantages which are inherent in the use of sodium as a reactor coolant apply to fast systems. They have an additional advantage in their ability to achieve high conversion ratios or to breed.

47. The research and development program for fast or epithermal liquid metal-cooled reactor systems is long range in nature and is expected to yield significant results in the late 1960's. In its initial stages, it will concentrate on the development of a satisfactory, long-life, high-burnup fuel material; on the utilization of plutonium and uranium 233 as fuels and of uranium and thorium as blanket materials; on the development of reliable and less expensive sodium components; and on the development of efficient and rapid fuel recycle methods.

Plans for use of existing or authorized facilities

48. *Domestic civilian power program.*—(*a*) Operation of the first experimental breeder reactor (EBR–1) at NRTS will be continued. Upon completion of the current safety experiments, a plutonium cermet core will be installed.

(*b*) The second experimental breeder reactor (EBR–II) at NRTS is scheduled for criticality in late 1960. The first core for this reactor will utilize U^{235} fuel. The subsequent core will be fueled with plutonium. This plant will incorporate onsite pyrometallurgical fuel processing.

(*c*) The 94-emw. Enrico Fermi plant at Monroe, Mich., is scheduled for criticality in 1960. Test information on the uranium 10 weight-percent molybdenum fuel performance, on fuel rotation, on fuel processing, on core physics, and on overall plant performance will be important to the advancement of fast reactor technology.

49. *Military contributions.*—(*a*) Various military research and development efforts will contribute significant data on fast breeder systems. The development work on the SNAP reactors (Systems for Nuclear Auxiliary Power) will result in the construction of a number of small sodium-cooled reactors which will provide information on the performance of fuel elements, moderators, and structural materials, operating at high temperatures in a fast neutron spectrum. The aircraft program includes the construction and operation of an experimental liquid metal cooled intermediate reactor. This facility will provide useful data on high temperature fuel element performance and on the behavior of other materials in a liquid metal environment.

50. Work being undertaken abroad also will contribute information of value to our program. The United Kingdom's Dounreay reactor is an experimental facility similar to a large EBR–1; they plan later to build a large fast breeder prototype. The French are planning a 10-mwt. advanced fast reactor using plutonium as fuel.

Future plans

51. A 100-mwe. prototype sodium-cooled fast or epithermal reactor will be constructed if the results from existing or planned reactors provide a basis for improved design. Two years of operating experience on these plants should be available before starting the new prototype. Detailed design and construction could start in 1963 or 1964. The primary purpose of this reactor will be to incorporate the improvements in design arising out of the operation of prior plants, and to demonstrate a plutonium-fueled core optimized for lowest power costs.

52. With the successful completion and operation of the above prototype and with data from other plants, it is believed that, by the late 1960's, enough information will be available to permit utilities to decide, on economic grounds, to construct large sodium-cooled fast breeder plants in many areas.

B. *Sodium-Cooled Thermal Reactors*

53. Sodium-cooled thermal reactors have the potential of achieving economic power in high fuel cost areas of the United States. These reactors can be operated at high temperatures and low pressures. However, to obtain full benefit from these characteristics, a greatly improved fuel element must be developed: one capable of long life in the high temperature environment. For this reason it is unlikely that this potential can be achieved at an early date.

54. Since sodium-cooled fast reactors offer most of the advantages of the sodium-cooled thermal systems and, in addition, offer the possibility of lower fuel costs through breeding, work on sodium-cooled thermal reactors would not be expanded until operating results from the Hallam reactor, now under construction, can be evaluated. Research and development for sodium-cooled thermal systems will concentrate on uranium carbide fuel development and on major improvements in the design, efficiency, and performance of the sodium components. In carrying out this program, full consideration will be given to the points of similarity between thermal and fast-cooled systems, and the work will be directed in such a way as to achieve maximum benefit to both.

Plans for the use of existing or authorized facilities

55. *Domestic civilian power program.*—(*a*) The Sodium Reactor Experiment (SRE) in California will be returned to operation. For the next several years, its use will be limited to testing of advanced fuels and other work in support of the Hallam plant. When this work is completed, and if the potential of the concept shows continued promise, the SRE will be reassessed as to its suitability for conversion to a high temperature fuel test facility, or to an advanced experimental reactor to demonstrate improvements in termal sodium-cooled systems.

(*b*) The Hallman (Nebr.) Nuclear Power Facility is secheduled to reach criticality early in 1962. Operational plans for this 75 mwe. plant include continued testing and evaluation of promising fuels, looking toward reduction in fuel cycle costs. Operating experience and tests with the plant are expected to yield valuable technical information regarding all sodium-cooled reactor plants, including those to operate with neutrons in the fast and intermediate energy spectrums.

Future plans

56. If evaluation of the operation and tests of the Hallman reactor shows a favorable potential for this concept, consideration will be given to the construction of experimental or prototype plants to exploit potential improvements. Such additional facilities will not be considered, however, until operating experience is available and therefore would not be initiated before 1963 or 1964.

IV. ENRICHED URANIUM GAS COOLED REACTOR PROGRAM

57. Enriched uranium gas-cooled reactors have the potential of producing superheated steam of the quality currently in use in large conventional central station powerplants with the resulting high efficiency. Gas-cooled reactors can operate at low pressure and therefore can be built in very large sizes.

58. The Commission has two approaches to the gas-cooled reactors program, exemplified by the 22.3 mwe. Experimental Gas Cooled Reactor (EGCR) now under construction and the Philadelphia Electric Co.'s 40 mwe. (28.5 mwe. with metal-clad fuel) High Temperature Gas-Cooled Reactor (HTGR). The HTGR will employ a core utilizing a graphite-clad fuel consisting of fully enriched uranium carbide and thorium carbide dispersed in graphite. The EGCR is a reactor utilizing stainless-steel-clad, slightly enriched UO_2 fuel. In the case of both reactors, heat is removed from the fuel by the helium coolant and is transmitted to a heat exchanger where steam is formed to drive the turbine. The graphite-clad system shows greater economic potential than the metal-clad system, but presents more difficult development problems.

59. The present and immediately foreseeable research and development program is concerned primarily with the design and construction of the EGCR and HTGR. Their construction and operation will make possible a more comprehensive evaluation of the potential of the gas-cooled reactor system. The program also will include investigations of fuel and cladding materials suitable for high burnup at fuel surface temperatures of 1,700° F. and higher and of alternate coolants.

Plans for existing and committed facilities

60. *Domestic civilian power program.*—(*a*) The 22.3 mwe. experimental gas cooled reactor (EGCR) at Oak Ridge is scheduled for criticality in 1962. This power-producing prototype will furnish statistically significant economic data on operation of gas-cooled reactors. It will be used as a flexible test facility which will permit the testing of advanced fuels, materials, and components suitable for use in future gas-cooled power reactors. Work on this project will be carried out in close cooperation with work of the United Kingdom on its advanced gas reactor (AGR).

(*b*) The Philadelphia Electric Co.'s 40 mwe. (initially 28.5 mwe.) high temperature gas cooled reactor (HTGR) is being designed and is scheduled for criticality in 1963. The work supporting this project includes development of impervious graphite, uranium carbide-thorium carbide fuel dispersed in graphite, high temperature components, and auxiliary systems including methods for trapping fission products which may get into the gas coolant.

61. *Military and maritime contributions.*—(*a*) The Commission's aircraft nuclear propulsion direct-cycle program is continuing to utilize the heat transfer reactor experiment No. 3 (HTRE–3) at NRTS. Present work is being concentrated on the review of HTRE–3 reactor design and its control system. Expansion of inpile component testing is underway at the engineering test reactor (ETR). High-temperature information developed by HTRE–3 will provide valuable information on fuel elements for gas reactor systems.

(*b*) The gas-cooled reactor experiment being constructed for the Army nuclear power program is scheduled to go critical this year. This facility will provide important data on core performance, particularly on small water-moderated, stainless-steel-clad, uranium dioxide cermet fuel cores and water-moderated uranium dioxide or uranium-beryllium oxides pellet cores. The use of nitrogen as coolant will be investigated. Closed-cycle gas turbine machinery will continue to be developed and tested.

(*c*) Development work on gas-cooled reactors for other special purposes, such as maritime propulsion, will continue to provide information important to the evaluation of the potential of gas-cooled reactor technology for large central station powerplants.

62. In addition much valuable information also will be obtained from our cooperative arrangements with the United Kingdom on the Dragon project. This is a high-temperature gas-cooled reactor to be built in the United Kingdom as a cooperative project with the Organization for European Economic Cooperation.

Future plans

63. Based upon the successful operation of the EGCR and the HTGR, a prototype to demonstrate advanced features will be initiated. An evaluation will determine the choice between the EGCR and the HTGR approaches. It is expected that this 100 mwe. prototype could be initiated in the middle 1960's.

64. It is believed that after operating experience is gained from the programed reactors, sufficient information will be available by the early 1970's to permit utilities to decide, on economic grounds, to construct in high fuel cost areas a 300- to 500-mwe. gas-cooled reactor using enriched fuel.

V. HEAVY WATER REACTOR PROGRAM

65. Heavy-water-moderated, natural-uranium-fueled reactors have a number of unique advantages. For example, they eliminate dependence upon diffusion plants in the fuel cycle, they have high neutron economy, and they require relatively small quantities of uranium ore per unit of power produced. On the other hand, these reactors are physically large with consequent high capital costs. The reactivity lifetime of the natural uranium fuel is more limited than that of enriched uranium fuel.

66. Several heavy-water-moderated reactors including prototypes using enriched fuel at this stage, but capable in larger sizes of operating on natural uranium are planned or are under construction in the United States. The Canadians are planning construction of both a 20 mwe. prototype, the NPD, and a 200-mwe. natural uranium heavy-water-moderated plant, the Candu. These plants are scheduled for criticality in 1961 and 1964, respectively. Negotiations are currently underway with the Canadians looking toward an expanded program for cooperation in the development of heavy-water reactors. Close

cooperation under this agreement will be mutually beneficial and, in addition, will serve to assist the Commission and U.S. industry in determining the future role of heavy-water reactors in this country.

67. The U.S. research and development program will be directed toward those problems which are critical to the evaluation of heavy-water-moderated systems. To the fullest extent possible, it will use pertinent information being developed in other programs and in other countries. The critical problems are those associated with reactivity limitations on fuel lifetime (including fuel management techniques for extending these limits), minimizing loss of heavy water, and techniques for fabricating components of pressure-tube or pressure-tank systems. One difficult design objective is to obtain the high coolant temperature needed for high thermal efficiency while maintaining the cool moderator necessary for long fuel-reactivity lifetime. The research and development program and cooperation with other countries will be planned so that the combined results will provide a sound basis for evaluation of this class of reactors, including designs which use coolants other than heavy water (e.g., organic and gas).

Plans for existing and authorized facilities

68. *Domestic civilian power program.*—(*a*) The heavy-water components test reactor (HWCTR), which, like the other projects now included in the heavy-water program, uses enriched fuel, is scheduled for criticality in 1961, at the Savannah River plant. This reactor will be used to obtain operating information on a heavy-water-moderated system under conditions similar to those that might be suitable for power production. It will provide irradiation tests on fuel elements being considered for heavy-water-moderated systems, and will provide tests of other components such as pumps, valves, and instrumentation.

(*b*) Research and development on a cooperative basis in support of the 50-mwe. reactor of the East Central and Florida West Coast Nuclear Groups will continue, looking toward an early evaluation, in accordance with the terms of the contract, and a determination as to whether or not the project will proceed with plant construction. If built, the reactor is scheduled for completion in 1963.

(*c*) A heavy-water-moderated and cooled-pressure-tube reactor of 17 mwe. capacity is being designed and is scheduled for criticality in 1962 in accordance with a contract between the Commission and the Carolinas-Virginia Nuclear Power Associates, Inc. This reactor will provide additional data on the performance of heavy-water reactors.

(*d*) The plutonium recycle test reactor (PRTR) is scheduled for criticality in 1960. This is an experimental facility to investigate the economic feasibility of plutonium recycling. However, the fact that this reactor uses heavy water as a coolant and moderator, incorporates a pressure tube design, and operates at power reactor temperatures, makes it an important source of additional information and technology.

Future plans

69. When operating and cost data are available from the United States and Canadian heavy-water reactors it is believed that there will be sufficient information to determine whether or not construction of a large heavy-water reactor is economically justified in high fuel cost areas of this country. We believe such an evaluation can be made by 1966 or 1967.

VI. AQUEOUS HOMOGENEOUS REACTOR PROGRAM

70. The aqueous-homogeneous reactor offers many advantages for production of power since it operates with a solution fuel, incorporates continuous fission product removal, and is largely self-regulating due to its large negative temperature coefficient. It further offers the possibility of breeding when operating on a thorium-uranium 233 fuel cycle. Major technical problems are associated with the corrosive nature of the fuel, stability of the fuel solution under irradiation, the maintenance problem associated with the radioactive primary loop, and the limited operating temperatures with the attendant low steam cycle efficiencies.

71. It is still too early to determine whether the simplicity of the fuel cycle and potential breeding will be more than offset by technical complexities and temperature limitations. Because of special advantages, research and development will be continued on the technical problems on a long-range basis.

Plans for use of existing facilities

72. *Domestic civilian reactor program.*—(*a*) Research and development work will concentrate on understanding and solving the fuel stability and corrosion problems in the core and on development of a suitable blanket material. Operation of the homogeneous reactor experiment nuclear (HRE–2) facility should be directed to aiding in the solution of the fuel stability, the remote maintenance and other basic system problems.

Future plans

73. The outcome of the research and development work will furnish guidance to the Commission in determining if a third aqueous-homogeneous-reactor experiment should be constructed. This experiment, if indicated as advisable, should be built in 1962–63 and should demonstrate breeding, or, as a minimum, a high conversion ratio. If the experiment proves successful a prototype of about 50-mwe. could be initiated in the late 1960's.

VII. NEW CONCEPTS PROGRAM

74. As technology is developing rapidly in many directions, the Commission must be alert to evaluate new reactor ideas as well as new ideas for major improvements in existing reactor types. However, a decision to proceed with the development of design alternates representing major technological advances depends upon an evaluation of the benefits expected to result. Such evaluation is difficult even when considerable technical data on each exists. Early construction of inexpensive reactor experiments may be justified to help determine the technical feasibility of advanced designs which look promising. The Boiling Reactor Experiment (Borax), the Organic Moderated Reactor Experiment (OMRE), and the Los Alamos Power Reactor Experiment (LAPRE) are examples of reactors built in minimum time at low cost to provide answers to specific questions as to technical feasibility.

75. The following reactor types or reactor modifications are typical of those currently being investigated. In several cases specific research and development is being carried out in areas critical to the evaluation:

(*a*) *Fused salt.*—This is a fluid fuel design based upon the use of a mixed salt solution of fissionable and fertile materials which is circulated from the reactor through an external heat exchanger. Potential advantages of this system are high thermal efficiency, low pressure and simplified fuel reprocessing.

(*b*) *Fluidized bed.*—This design is based upon maintaining a bed of fissionable and fertile material in a fluidized state under turbulent flow conditions. Organic material or water are considered as possible fluidizers and coolants. High power density and ease of charging and discharging fuel are potential advantages of this system.

(*c*) *Paste or suspended fuel.*—This design is similar to the fluidized bed design except that the bed is maintained in a laminar, nonturbulent condition, and is internally cooled by a separate coolant. Many of the potential advantages of the fluidized bed are retained. In addition, because of the nonturbulence, particle attrition is reduced and reactor control may prove to be easier.

(*d*) *Supercritical water cooled.*—A reactor based upon this concept would operate at extremely high pressure, avoiding the phase change associated with boiling yet permitting the generation of superheated steam external to the reactor. High thermal cycle efficiency is the potential advantage of this alternate.

(*e*) *Slurry.*—This design is based on a fluid fuel system in which the particle size of the fissionable or fertile material is so small that it forms a suspension under operating conditions. The reactor may be cooled externally or internally. The carrier fluids undergoing most active investigation are water and liquid metals. The potential advantages of this concept are similar to those cited for other fluid fuel reactors.

(*f*) *Advanced epithermal.*—A compromise design between sodium-cooled fast reactors and sodium-cooled thermal reactors may have advantages over either—particularly for the thorium fuel cycle. This design would include some moderation by graphite or beryllium, optimized for high conversion ratio with uranium-233 fuel consistent with economic promise. High thermal efficiency and low pressure characteristics of sodium-cooled system would be retained.

(*g*) *Pebble bed gas cooled.*—In this concept a stationary bed of balls (or pebbles) containing the fissionable, fertile and moderator materials is cooled by

a gas. Potential advantages are in the area of low fuel cycle costs, and high thermal efficiency.

(*h*) *Solid moderated, steam-cooled reactors.*—In this concept, heat from the fuel is radiated to the moderator (graphite beryllium oxide, zirconium hydride, etc.) which in turn is cooled by water or steam. High thermal efficiency is the principal potential advantage.

(*i*) *Alternate coolant fast reactors.*—This design is similar to the sodium-cooled fast reactor except that alternate coolants are being considered. These include mercury, lead, lithium, sulfur, and other materials. It is believed that with certain of the alternate coolants increased efficiency and reduced costs may be attainable.

Plans with respect to existing or authorized facilities

76. *Domestic civilian power program.*—(*a*) The Los Alamos Molten Plutonium Reactor Experiment (LAMPRE) is under construction. It will be operated to demonstrate the technical feasibility of a fast reactor using a fluid or molten fuel.

(*b*) The High Temperature Gas Cooled Reactor Experiment (Turret) is under design at Los Alamos, would establish the feasibility of operation with a gas coolant at temperatures above 2,000° F. An attempt will be made to handle a very radioactive primary system. This reactor might have direct application in supplying process heat to the chemical and metallurgical industries.

Future plans

77. Engineering studies, research and development, and evaluation of the new reactor concepts will be continued to the point where a decision can be reached either to build a reactor experiment or to terminate the work. During the next few years it is probable that three to five of these concepts will have reached a point where construction of a reactor experiment will be justified. Subsequent evaluation of the results from these experiments may justify the construction of several prototypes.

VIII. NUCLEAR TECHNOLOGY

78. In addition to the specific work carried on under individual power reactor projects, there is an area of more broadly based development in nuclear technology. The general objectives of this program are to provide basic data on reactor systems and related problems, to carry out engineering development of a general and fundamental nature, to investigate the feasibility and potential of new methods for improving reactors, and to provide tools, such as test and research reactors and remote handling devices, for use in reactor research and development.

79. Developments in this area should help to lower the cost of nuclear power generation through improvements affecting many types of reactors and through reductions in the overall cost of the reactor fuel cycle.

A. *Fuels and materials*

80. Research in this category is directed toward evaluating the potential of materials for reactor applications, determining their basic properties and developing engineering design information on nuclear fuels and reactor materials. This work will result in more efficient utilization of nuclear fuels and reactor materials in reactor cores.

81. In this field, the fuel cycle development program was established to concentrate research effort on reduction of nuclear power costs through improvements in fuel performance and reductions in fuel costs. During fiscal year 1959, 24 research and development proposals submitted by industrial organizations in response to public invitation were accepted. Additional work was assigned to National Laboratories and the research effort of other contractors was increased. Research necessary to reduce the oveall fuel cycle cost includes an intensive effort to increase reactor core life and fuel burnup, increase the irradiation stability of nuclear fuel, reduce fuel fabrication costs, and attain higher temperature opeation of fuel assemblies. Specific plans under these programs are as follows:

(*a*) The development of basic engineering information concerning alloys of fissionable elements, uranium oxide, uranium carbide, and plutonium- and thorium-bearing ceramic fuels will be actively pursued. In particular, additional data are required on the properties of materials at the maximum temperatures contemplated for their use.

(*b*) The effect of radiation upon the properties and performance of reactor materials will be determined with particular attention to the effects of long-term irradiation.

(*c*) To facilitate reductions in fuel cycle costs, the search for improved fabrication methods and simplified fuel element concepts to reduce fuel element fabrication costs will be emphasized.

(*d*) Research directed toward understanding the mechanisms of release or retention of fission gases will be increased in the hope of extending the useful reactor life of nuclear fuels and achieving higher fuel temperatures.

(*e*) Knowledge will be sought on the behavior of oxide fuel elements under irradiation at temperatures that result in central melting, or vapor phase movement of the fuel, in order to establish the feasibility of reactor operations under these conditions.

(*f*) Research on nondestructive testing techniques and on the development of improved nondestructive testing equipment will be continued.

B. *Fuel Reprocessing*

82. This effort places principal emphasis on reducing the cost of reprocessing current reactor fuels and on developing techniques for processing advanced fuels in proportion to their potential. These objectives include the development and demonstration of methods for power reactor fuel reprocessing which will make possible the eventual entry of private industry into this area. At this time, proven technologies do not exist for many fuels. The demonstration program now planned will define these technologies more clearly while exploring promising alternates.

83. The program in the closed fuel cycle concept, consisting of low decontamination processing and remote refabrication, presently emphasizes pyrometallurgical techniques. It is being carried out partly as backup to the EBR–II concept, and partly in exploration of the degree to which this radical new approach to the entire fuel cycle will find application in other power reactor systems. The increasing importance of high burnup lessens the significance of fission product poisoning; at the same time direct handling of recycled fissionable materials becomes more difficult due to gamma and beta active isotopic contamination. If economics can be favorably demonstrated the closed cycle approach wil be more compatible with these developments than the conventional direct fabrication cycle, and in addition will offer the possibility of reducing external fuel inventory charges.

C. *Environmental Investigations and Waste Disposal*

84. The principal objective of this program is the engineering development of practical systems for the safe handling and disposal of the wide variety of radioactive wastes evolved from nuclear energy activities. To meet this objective requires the accumulation of quantitative information obtained from a broad program of both laboratory and field investigations ranging from evaluation of the behavior and fate of radioactive materials that may be dispersed in specific environments (air, ground, and water), to development of techniques and systems for concentrating and fixing large quantities of radioactive materials in solid form suitable for ultimate, long-term disposal in specially selected locations.

Accordingly the projects in this program include specific river, atmospheric, marine, and hydrogeologic studies on a wide geographic scale; laboratory and pilot scale studies of waste fixation schemes; and supporting laboratory investigations. The transition to prototype field and engineering projects will continue to be a significant feature of the program in the future. The results of this work are also essential for developing data related to the environmental aspects of the location, design, and operation of nuclear reactors and associated facilities.

D. *Physics*

85. The physics program will be directed toward the development of fundamental physics data on reactor materials such as cross-section measurements of reactor materials, physics experiments aimed at improved core design and better reactivity control, and other fundamental studies to improve reactor design. This work will include research on the isotopic composition of high burnup fuel and on the effect on reactivity lifetime of fissionable isotopes and fission-produced poisons generated during long-term exposure.

E. *Reactor Components, and Associated Equipment*

86. The reactor components program is directed toward the solution of fundamental engineering problems applicable to all reactor concepts and toward the development of components generally useful in power reactors. It consists of the following:

(*a*) Increased emphasis will be placed on development of means for obtaining higher heat transfer rates in reactor coolants, so that full advantage may be taken of the improved heat flux and temperatures available from high power density cores.

(*b*) A major effort will be initiated to develop instruments, both in-core and out-of-core, to measure reactor performance, with special emphasis on measuring fuel burnup and detecting fuel failures, as well as on improved methods of measuring coolant flow rate, temperature, pressure and steam void fraction.

(*c*) Fuel-handling equipment will be developed which will make possible the interchange and remote removal and replacement of reactor fuel element assemblies without necessitating reactor shutdown. Work will also be continued on equipment for remote fabrication of fuel elements incorporating highly radioactive recycled nuclear fuels.

(*d*) Basic development of mechanical components will be undertaken to provide pumps, compressors, valves, seals, and other items for use in high-temperature gas reactor systems. Work will be continued on development of improved pressure vessel and heat exchanger design and fabricating techniques to reduce the cost and increase the reliability of this equipment, and to determine the effects of neutron radiation on these structures. Techniques will be developed for remotely inspecting and testing pressure equipment after long periods of service in radiation environments.

F. *Reactor Safety*

87. Problems in reactor safety will intensify by virtue of the increasing number of new reactors and the growing diversity of types. The reactor safety program will continue the experimental and analytical work required to provide a sound technical basis for safe and economical reactor design. The principal categories of work will deal with reactor kinetics and transient tests, hazardous chemical reactions including fission product release, and reactor containment. A major objective of the work is to develop information which may be used not only for developing sound theoretical models for predicting reactor behavior but which also may be useful in establishing criteria and standards for the safe design and operation of reactors.

(*a*) The reactor kinetics program will continue with the operation of the SPERT (Special Power Excursion Reactor Test) series of reactors and the KEWB (Kinetic Experiments on Water Boilers) reactor. The SPERT reactors are designed to obtain transient test data for the full range of heterogeneous water reactors, including swimming pool, boiling water, heavy water, and pressurized water reactors. An additional feature of the SPERT II reactor is the ease with which it can be modified to conduct transient testing of organic systems. Major effort under the SPERT program will be made to obtain data and mathematical models which will be useful not only in design and for hazards analysis of reactors but also in establishing standard test procedures for proving the dynamic characteristics of new reactors before they are licensed for operation.

(*b*) The KEWB program should be completed in calendar year 1961 with the test of a cylindrical core. KEWB data will have wide application not only to an understanding of homogeneous reactor kinetics but also to safety analysis of chemical-processing plants.

(*c*) Additional support work will be provided to the reactor transient testing program in the field of kinetics analysis, transient heat transfer, and bubble dynamics.

APPENDIX A

1. SL–1647, Power Cost Normalization Studies.
2. Status Report on Boiling Water Reactors.
3. Status Report on Heavy-Water-Moderated Reactors.
4. Status Report on Organic-Cooled Reactors.
5. Status Report on Pressurized Water Reactors.
6. Status Report on Fast Reactors.

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7. Status Report on Aqueous Homogeneous Reactors.
8. Status Report on Sodium Graphite Reactors.
9. Status Report on Gas-Cooled Reactors.

(*d*) The efforts to determine the true hazard of metal-water reactions will try to correlate laboratory tests and theory with capsule-type inpile experiments and, finally, full-scale core meltdown measurements. Fission product release studies will be made inpile for the first time and generalized theories developed to allow accurate prediction of both fission product release and metal-water reaction in any credible accident.

(*e*) The high cost of containment design will be attacked by investigations of alternate methods of protection such as confinement in ordinary buildings, and the use of energy sinks and vapor suppression schemes. In addition, data and theories of the response of containment structures to dynamic loading will continue to be investigated in order to eliminate any excessively conservative design criteria and their concomitant excessive costs.

IX. COSTS

88. The Commission has attempted, for planning purposes only, to forecast the level of costs for research and development, design and construction of experiments and prototypes, operation costs, waivers of fuel charges, and general engineering support of the civilian power program. The years immediately ahead are more easily estimated, of course, than the years later in the effort to achieve economic power. Gross total costs, including prototype but not commercial-size plants, are forecast to average between $180 million and $200 million a year. The bulk of the expenditures probably will be made by the Government, but industry is expected to make a substantial contribution.

ADDITIONAL REACTOR PROGRAMS

89. Concluding our presentation of the Commission's civilian power reactor program, I would like to summarize a few additional reactor programs, in some of which the committee has expressed special interest.

90. *Test reactors.*—Most fuel irradiation tests requiring thermal neutrons are now conducted in the Commission's materials testing and engineering test reactors. Some smaller Commission reactors also are being used for this purpose, and a few privately financed test reactors, such as those of Westinghouse and General Electric, have become available. Last year, the Commission sought to obtain a greater portion of its irradiation test needs from industry. As a result of an invitation the Babcock & Wilcox Co. proposal was selected as a basis for negotiation of a contract for use of space in a reactor to be constructed.

91. Due to the increasing needs, particularly in the Navy program, for thermal fluxes higher than available in existing or planned test reactors, the Commission, in August, contracted with Phillips Petroleum Co. for a conceptual design study for a high-flux test reactor incorporating the most advanced technology available. During the coming year the possible requirements for fast breeder fuel element test facilities will be studied.

92. Industry's and the Government's requirements for irradiation space in test reactors in the period 1960 through 1965 are being evaluated. The results will serve as a basis for determining the nature of arrangements for building a high-flux test reactor.

93. *Process heat.*—One reactor development effort not directly associated with the generation of electricity is our program to develop nuclear reactors for industrial process heat. As indicated previously, the Commission has undertaken design and construction of a 40-mwt. pressurized water reactor to produce low-temperature process steam. The Department of the Interior will build an associated experimental plant in California which will use heat from this reactor to convert saline water to potable water.

94. Work on high-temperature process heat is being carried on in a joint experimental program between the Commission and the Bureau of Mines at the latter's Appalachian Experiment Station, Morgantown, W. Va. The ultimate objective is use of heat from a nuclear reactor for gasification of coal. The previously described high-temperature, gas-cooled reactor experiment, designated "Turret," is a possible source of high-temperature industrial process heat.

95. *Thorium utilization.*—Four reactors discussed under specific concepts in part IV are scheduled to utilize thorium. These are the sodium reactor experi-

ment, and the power reactors of Consolidated Edison, Rural Cooperative Power Association, and the Philadelphia Electric Co. Operating experience from these four plants and further development and testing at the homogeneous reactor experiment, will provide a base for further evaluation. Should evaluation indicate a potential justifying further experimental or prototype reactors designed primarily for thorium utilization, necessary authorizations would be requested.

96. Specific problems of thorium utilization include fuel stability, corrosion, and the development of slurry or other systems suitable for fluid fuel thorium breeders.

97. *Contributions of military reactor programs.*—The military reactor programs have been of industrial importance from their inception. They have contributed, and on an increasing scale continue to contribute, technical information to the civilian reactor programs.

98. The naval reactors program has made many direct contributions. The pressurized water reactor, for instance, was selected for the Shippinport plant because full advantage could be taken of technology developed in the naval program.

99. All water-cooled reactors benefit from past development of the naval reactors program. Sodium technology and components were first developed for the submarine intermediate reactor.

100. The Army reactors program contributes to development of small powerplants for civilian purposes. Low-output plants provide a significant portion of the power generated today in this country. The Army objectives of ease of installation, operation, and maintenance, and minimum crew size and training requirements, are directly applicable to small civilian plants, particularly in remote locations. Among specific developments from the Army program are stainless-steel, uranium oxide plate fuel elements and control rod drives, both subsequently used in the civilian program. The portable gas-cooled reactor MI–1 will be the first plant in operation which combines a reactor heat source with a closed gas-turbine cycle.

101. The aircraft reactors program, which includes the direct-cycle, indirect-cycle, Rover, Pluto, and Snap projects, has provided much new and extremely useful information to civilian reactor technology. These projects have been the major source of data on very high temperature effects on reactor materials, and components. This program also produces very useful data in the lower temperature ranges on shielding and on the effects of radiation on organic materials.

102. Radioisotope power technology developed under the Snap program is readily usable for special power applications such as remote unattended weather stations. Technology in power conversion has also been advanced by research in thermoelectric and small power conversion equipment. Progress is being made by the Rover advanced concept group at Los Alamos in their research on a very promising energy conversion device—the plasma thermocouple.

103. During the past year, a revised classification guide permitted release of additional information about military reactors. As a result, only that information which reveals features essential to the design, construction, or operation of specific military reactors remains classified. The aircraft reactor experiment at Oak Ridge National Laboratory was completely declassified, as was the aircraft reactor test there, and the supercritical water reactor.

104. Information declassified and available from these reactor programs includes fused salt fuels and liquid metals technology such as the compatibility with stainless steel of sodium, sodium-potassium, bismuth and lead. In addition, technology associated with the nichrome V fuel element designed for the direct-cycle reactor has been declassified and information on the behavior of this material in a reactor environment will soon be made available.

105. These declassified research and development documents are made available to the public through our standard distribution channels and contribute materially to industrial knowledge.

106. *Maritime program.*—The effect of the maritime reactors program thus far has been chiefly upon the industrial and official bodies associated with the development, design, construction, and forthcoming test operation of the NS *Savannah*—the world's first nuclear-powered mechant ship. These groups range from the reactor designer, naval architect, and shipbuilder to the regulatory bodies and local port authorities in the United States and abroad.

107. From the inception of the *Savannah* project, normal commercial practice has been followed in order to establish procedures for possible future nuclear

vessels. The crew has been selected from the officers and men of the American merchant marine. The ship is being constructed in accordance with established codes and regulations of both marine and nuclear industries.

EVALUATION OF FOREIGN NUCLEAR POWER PROGRAM

108. Before leaving the subject of reactors, I would like to give a brief evaluation of foreign activities on power reactors.

109. The joint power reactor program between the United States and the European Atomic Energy Community has not developed to the extent originally expected. Factors with which you are acquainted have sharply reduced the original urgency for immediate construction of large-scale nuclear powerplants of some 1 million kilowatts total capacity.

110. Long-term interest in nuclear power is continuing, but the emphasis is shifting in Western Europe, as elsewhere, to technological developments leading toward the reduction of costs rather than to early large-scale construction.

111. Only one definitive proposal (that of the Italian utility, Senn) was received in the joint U.S.-Euratom nuclear-power reactor program by the deadline of last October. Our staff in Brussels is assisting the Euratom staff in working with the representatives of the Franco-Belgian group, which has reaffirmed its intention and ability to submit a definitive proposal. Completion of the project would run over the December 31, 1963, deadline, but still could be undertaken in the second phase of the program which calls for completion by December 31, 1965.

112. The German utility study group, AKS (Arbeitsgemeinschaft Kernkraftwerkes Stuttgart), had advised it can no longer hold out the promise of a binding commitment for the construction of a nuclear-power plant under the joint program. Therefore, this project will not be included in the 1963 phase of the program and may be out permanently.

113. The Commission has carefully considered the Euratom program in light of the present circumstances. The U.S. policy on the importance of European economic and political integration has not changed. Euratom fosters such integration, while the need for nuclear power as an immediate additional power source in Europe has lessened, the construction and operation of American-designed nuclear plants in Western Europe by the end of 1965 would still be of some technological benefit to the United States. These benefits would include the opportunity for additional demonstration of reactor concepts developed in the United States. In the interim, engineering and fabrication of such plants, and the creation of new facilities where improvements may be tried and demonstrated, will be useful to our technology. The operation of such plants will provide statistical information on fuels and reactor performance which would be of value.

114. We have approved the Senn proposal recommended to us by the U.S.-Euratom Joint Reactor Board as a generally satisfactory project and as an acceptable basis for development of such necessary subordinate arrangements as the Euratom-Senn contract, the fuel-cycle guarantee contract, and the U.S. fuel supply plutonium purchase and reprocessing contracts. When these arrangements become definitive, we shall request congressional authorization of the appropriate fuel-cycle guarantee.

115. With respect to the two reactors currently authorized for 1965, we continue to believe that an invitation should be issued at an appropriate time.

116. The joint research and development program supported by the United States and Euratom gained widespread attention in this country and in the European Community. To date, proposals with a dollar value of almost $3.34 million have been approved by the Joint Research and Development Board. Of this, $1.7 million worth will be performed in the United States at our expense. A total of $600,000 has already been contracted for and the remainder is in negotiation. Similarly, Euratom has contracted for about $449,000 of the $1.65 million to be done in Europe, with the remainder in negotiation. All of the proposals approved so far, both for U.S. and Euratom financing, cover research and development related to water reactors, chiefly in the field of fuel-cycle studies.

117. We propose to continue the research and development program, but limit it to a modest amount in connection with the Senn project. This limitation would apply until responsive proposals to build reactors have been received in connection with invitations for 1965.

118. Apart from continuing the joint reactor program and its associated joint research and development program within their present framework, we will, of course, keep in close consultation with Euratom for the purpose of identifying any additional cooperation which would be of mutual technical benefit.

119. The situation in India and Japan differs somewhat from that in Europe. Both of these nations believe that nuclear power may be economic or nearly so in some of their high cost areas at the present time. India is studying a nuclear-power program which might be incorporated in its third year of its 5-year program and has held discussions with us on their plans. They plan to solicit this year on a worldwide basis, bids for a 250-mwe. reactor to utilize natural uranium. Japan has contracted for a full-scale reactor of the Calder Hall type, is negotiating a contract for the purchase of a boiling water prototype reactor of 12 mwe., and is reported to have an interest in a large-scale reactor of the water-moderated type. While these activities are encouraging, we believe it is still too early to predict to what extent and on what time schedule substantial nuclear-power programs may get underway in either of these countries.

120. The nuclear-power program of the United Kingdom is approximately on their current schedule of obtaining 5 to 6 million kilowatts' capacity by 1966.

121. On my recent visit to the Soviet Union, I learned that the U.S.S.R. will install only the first of the two reactors planned for the Voronezh nuclear power station and only two of the four scheduled for Beloyarsk. Also, the Leningrad nuclear power station apparently will not be constructed until the first reactor at Voronezh has been operating. Thus, stretchouts from their 1955 and 1958 construction plans are apparent, as I'm sure some members of the Joint Committee learned on their trips to the Soviet Union. As far as we know, the U.S.S.R. dual-purpose reactor program is not involved in these stretchouts. I should note, also, that for reactors in the 5- to 50-emw. range are to be built at Ulyanovsk; the site is now being prepared for these reactors and they are to be completed in 1962–64. The U.S.S.R. is reported to be building a 97-emw. nuclear powerplant for Czechoslovakia and the 70-emw powerplant in East Germany, expected to go into operation in 1963–65.

122. Our testimony, of course, has reviewed only a portion of our international atomic activities—those related to nuclear power. We are lending every assistance to the study on international activities in atomic energy being carried out for this committee by Mr. Robert McKinney. We will be interested in the results of this study.

INDUSTRIAL ACTIVITIES

123. In considering the development, growth, and state of the atomic energy industry in the United States we are glad to report that the industry continues to grow.

124. An index of this growth is to be found in the most recent Joint Commission-Bureau of Census annual survey of shipments of key atomic energy products from private manufacturing establishments during 1958. It showed a 55-percent growth in such shipments over 1957.

125. The heaviest industrial impact of atomic energy work comes, of course, from construction of nuclear reactors. Data based on a quarterly Commission survey indicate civilian and military reactor projects under construction or active development as of September 30, 1959, including both Government and private projects, represented total commitments of more than $1.7 billion. This figure includes about $320 million for research and development work directly related to specific reactors.

126. Let me make clear that the survey on which these figures are based covers only projects which actually are under construction or active development, and excludes projects already completed, such as Shippingport, and projects announced as planned but which are not yet in design stages.

127. About $1 billion of the $1.7 billion total is for civilian projects, the remaining $700 million for military projects. Propulsion reactors for naval vessels account for about two-thirds of the military total. The bulk of the money still remains to be spent. We believe this represents a conservative estimate of the level of reactor activity, since the dollar figures do not include projects for propulsion of aircraft, critical experiments, small training reactors, and general research and development work.

128. Eighteen reactor experiments and prototypes directed toward production of economical nuclear power accounted for $717 million. The Commission's support totaled $252 million and electric utilities were financing $465 million.

129. The Commission, under the provisions of the Atomic Energy Act, has a responsibility to encourage widespread use of atomic energy in such a manner as to strengthen free competition in private enterprise.

130. From its inception the Commission has turned to private industry to construct its facilities, and to industrial companies and educational institutions for their operation.

131. It continues to be Commission policy, announced first in 1956, that the Commission will cease to provide any service or product to the public whenever they can be provided under reasonable terms by private industry.

132. The Commission also has maintained a firm policy of procuring goods and services from private industry wherever practical.

133. As you know, there has been discussion recently regarding the Bureau of the Budget Bulletin 60–2, issued last September, in modification of previous bulletins on the same subject. This bulletin states that generally the Federal Government should not start or carry on any commercial industrial activity to provide a service or product for its own use if they can be procured from private enterprise through ordinary business channels.

134. We received letters from industrial groups asking that we review certain of our activities from the standpoint of the bulletin. Our response to industry has been placed before this committee.

135. During 1959, the Commission took further action to increase private participation in atomic energy work. For example, it continued efforts to procure fuel fabrication and processing services from private firms wherever possible. As a result, Commission contracts for such service valued at about $40 million were let during the year.

136. The Commission also increased use of private facilities for recovery of unirradiated scrap.

ISOTOPES DEVELOPMENT

137. The Commission has reported to the Congress frequently on the steadily increasing use of radioisotopes in agriculture, medicine, and industry. In the interest of informing this committee of the current status of radioisotopes technology and application we have submitted to you a special report on radioisotopes in science and industry. I believe the report will prove of considerable interest to you as well as bringing more fully to public awareness the ever-increasing influence of radioisotope technology in so many facets of our daily lives.

138. The report illustrates the large range of possible radioisotope applications. I would like to mention elimination of agricultural pests as an example. The radiation from radioisotopes has been the means for wiping out the screw worm fly from Florida and the Southeastern United States, where ranchers formerly suffered $15 million to $25 million annual loss due to this pest. Work is being carried out in this and other countries of the world to determine whether or not this same technique can be successfully applied to the elimination of other types of pests, such as boll weevil, Mediterranean, oriental, and melon flies. Insect damage to agricultural crops and domestic animals in the United States amounts to approximately $4 billion annually.

139. We feel it is particularly important to realize that while the basic principles of isotope use have been known for about 25 years and we have made important progress in certain areas of use, their broad application is, with limited exceptions, relatively unexploited. In recognition of the benefits which can accrue from widespread use of radioisotopes, the Commission, late in 1958, expanded its isotopes program to put isotopes to work more fully for man's scientific and engineering progress.

140. The Commission, under its expanded program to develop isotope principles and technology, has established three objectives: First, to fill the gap between basic and applied research in isotopes by carrying out developmental research; second, to reduce the time lag between conception of a new principle and its practical application; and, third, to create a broad base of new and improved technology so that uses of radioisotopes and radiation in industry, in agriculture, in medicine, and in research can be extended and speeded up.

141. The Commission sponsors work aimed at these objectives by a number of regional university centers, by private laboratories, by our own national laboratories, and by a limited number of industrial organizations and other Government agencies. Usually, the Commission carries forward the work only to the point of demonstrating the feasibility of a new principle for using the isotope;

further development, such as engineering, becomes the responsibility of private industry. In special cases, the Commission may support development of a "proof of principle" working model.

142. We have now had a year's experience with the expanded isotopes program. Our emphasis has been placed upon developing technology—the technology of using isotopes and of applying radiation to industrial processes, as well as upon improving methods of radioisotope production and preparation. This program is supported by the addition of training courses for industry.

143. Much of the isotope technology we are studying will bear directly on problems of public concern, as in the areas of water resources, weather, air pollution, and industrial waste treatment and disposal.

144. During the past year, we have entered into research and development contracts covering a wide range of technical projects. One example is a cooperative effort with the Weather Bureau to build an isotope-powered, unmanned weather station to continuously transmit weather information from remote locations. Weather data is a matter of universal interest and recently has become a common scientific meeting ground for all nations. The use of dependable, long-lived radioisotope power sources for unmanned weather stations would make possible a major advance in the science of weather predictions. This would permit continuous collection of weather data from regions, such as the Arctic, where it was previously impossible.

145. An investigation of importance to atmospheric pollution determinations involves development of an analyzer for detecting contaminants in concentrations as low as 10 parts per billion. Under present procedures, data collection and analysis are slow and expensive to obtain. Smog control groups have emphasized their need for automatic, sensitive analyzers that will permit quick collection of data and implementation of control procedures. Under the isotopes program, we are developing a unique analyzer using the fission product gas krypton–85 to measure directly the concentration of atmospheric contaminants such as sulfur dioxide and oxide. This principle would provide a tool that would assist control of this national problem.

146. The discovery, development, and conservation of water resources is a matter of primary interest not only in the United States but in many parts of the world. Problems vary from those of the arid zones of the world where the emphasis is on exploration, to those of highly industrialized regions where water demand was overtaken a previously adequate supply. Radioisotopes offer unique tools for increased understanding of underground flow of water, and many more water resource factors such as rainfall, runoff, ground water recharge, and waste discharge. This, in turn, will provide better understanding of the effects of those factors on reservoir development, land use, flood control, and quality of water. We have been working closely with U.S. Geological Survey and other groups in carrying out a systematic study of how nuclear techniques may be used in solving water resources problems.

147. The program on industrial process radiation aims at putting to work the energy of massive quantities—millions of curies—of ionizing radiation. Sources of such radiation are fission byproducts, reactor produced isotopes, and nuclear reactors.

148. In this field, we are exploring a basic scientific problem—the interaction of radiation and matter. Design of radiation sources for various specific processes is another broad area being worked out. Additionally, we will focus attention on processes including chemical, physical, and biological changes of potential industrial interest that might be induced by ionizing radiation.

149. An example of the type of work which we are carrying out is initial research and development to establish the feasibility of producing chemicals with nuclear reactors—a reactor that might be described as a chemical factory. For example, it has been demonstrated that when mixtures of nitrogen and oxygen—normal constituents of the atmosphere—are passed through the core of a reactor under certain conditions, nitric acid is produced. Production of other chemicals of importance in the national economy, and even new products not now in existence, are among the possibilities. However, we are presently only at the very earliest research threshold of developing nuclear reactors into producers of bulk chemicals.

150. Massive quantities of radiation energy may also be a means of converting coal into valuable new chemicals, and accordingly develop new markets for coal products. The Commission and the Bureau of Mines have therefore entered into a cooperative agreement for conducting research and develop-

ment on beneficial radiation effects on coal and other natural resources. The Commission is providing a 100,000 curie cobalt–60 source for this project and will provide technical assistance. The Bureau of Mines is providing the necessary facilities and equipment and will carry out the experimental work. We believe this research may result in determining means of improving the utilization of the nation's coal and other resources.

151. Under the program for production and process development, radioisotopes and radiation sources are produced in Commission facilities to meet the changing needs of advancing science and technology. In pricing of radiosotopes, our objectives are to provide reasonable compensation to the Government, stimulate private sources of isotope supply, and encourage research and development.

152. During the year, the Commission substantially increased the quantities of tritium and krypton–85 for civilian use—1 million curies of tritium and 100,000 curies of krypton. Studies performed during the year also have established the economic feasibility of producing radioisotopes in power reactors.

153. To provide increased opportunities in isotope technology training, the Commission established a special industrial radioisotope course at Oak Ridge. During 1959, three 6-week courses were attended by 100 industrial scientists and engineers. Among other educational activities, 7 regional workshops on the industrial uses of radioisotopes were attended by more than 1,500 scientists and engineers.

REGULATORY ACTIVITIES

154. In all the Commission's regulatory activities, protection of public health and safety is paramount. Our aim is to provide such protection through simple and economical processes which impose a minimum burden upon those who are regulated.

155. Many of the Commission's regulatory activities were based upon plans necessarily developed in advance of practical experience. Based on growing experience, we have initiated steps to—

(1) Realine our organization for regulatory activities;

(2) Clarify and simplify our regulatory procedures; and

(3) Refine our safety and health criteria and standards, particularly those bearing upon construction and operation of the very large reactors, the power and test reactors.

156. To improve our internal organization, the Commission's regulatory programs have been brought together under a new position of Assistant General Manager for Regulation and Safety. In filling this new post, the Commission obtained the services of Mr. William F. Finan, formerly Assistant Director for Management and Organization of the Bureau of the Budget. The units involved in the reorganization are the existing Division of Licensing and Regulation, and the recently formed Office of Health and Safety, which will develop health and safety standards. This Office is presently working with the States looking to the transfer to them, under Public Law 86–373, of some regulatory duties.

157. Direct inspection of licensees for compliance with regulations will be transferred from the Inspection Division and placed in a new Divison of Compliance under the Assistant General Manager for Regulation and Safety. The Inspection Division will, of course, retain its overall statutory responsibilities.

158. The already heavy workload of the Advisory Committee on Reactor Safeguards will undoubtedly will continue to grow. To enable the Committee to handle this workload, the Commission and the Advisory Committee on Reactor Safeguards are working together to simplify and strengthen working arrangements between the Committee and Commission staff.

159. The steps we are taking to improve procedures are directed particularly toward licensing of large power and test reactors. Experience with our early regulations have proved them to be too general. They are silent on some points in which prospective licensees and the public need information. The Commission a few days ago published for public comment three proposed regulations modifying its reactor licensing policies and procedures.

160. The first proposed change would define the point at which a permit for reactor construction must be obtained. It would allow component procurement, site acquisition, and clearance and excavation, but not the pouring of foundations, before issuance of a construction permit.

161. The second proposed change in the regulations would clarify the requirements to be met for issuance of construction permits recognizing, however, that most decisions shall be based on case-by-case considerations while the develop-

mental stage in reactor technology continues. Permits may be issued on a provisional basis if there is reasonable assurance that the proposed site is suitable from a safety standpoint for a reactor of the power level and general design concept proposed. This may be done, even though there remains to be performed research and development work on some design questions affecting safety, upon a showing that the applicant will conduct a research and development program on these questions. The applicant may apply at any time for an amendment to his permit granting approval of satisfactorily resolved design features.

162. The third proposed amendment grows out of an experience with Dresden. It is designed to facilitate the conversion of a reactor construction permit to an operating license. Under the statute a final operating license cannot be issued until after the Commission makes a finding of completion of construction. In the normal course of reactor construction, the construction necessary for initial loading and testing is completed just prior to loading, and some construction cannot be completed until after nuclear operational tests. Licensing procedures and hearings at the loading stage would unduly delay startup of the plant.

163. This proposed amendment provides for the issuance of a provisional operating license as much as 90 days in advance of scheduled startup so that the transition may be made from construction to operation without unnecessary delay while giving full emphasis on public health and safety. The provisional operating license will also facilitate the conversion from construction permit to operating license where features of the reactor make it desirable to obtain actual operating experience before issuance of an operating license for a period of years.

164. Looking into the future, it seems clear to us that reasonably full attainment of the regulatory objectives of the Atomic Energy Act will require that the Commission issue regulations containing progressively comprehensive licensing criteria and standards to cover every aspect of atomic energy activities. Public understanding and broad acceptance of these criteria and standards will be vital to their success.

165. Several years ago the Commission established detailed health and safety standards relating to permissible exposures to radiation. Based on revised recommendations of the National Committee on Radiation Protection and Measurement, the Commission some months ago issued for public comment proposed changes in its regulations. In view of the extensive public interest and numerous suggestions received, the period for public comment was twice extended, and further revisions are being made in the proposed amendments.

166. Last February the Commission amended its regulations to provide a simplified licensing procedure applicable to the use of gaging, measuring, and controlling devices containing radioisotopes. It is the Commission's experience that many of these devices can be designed so that they may be safely operated by persons not trained in radiation perfection. Under the amended regulation, the user does not have to apply for a specific license provided that suppliers obtain specific licenses authorizing the manufacture and distribution of the devices.

167. Within the near future, the Commission expects to seek public comment on two proposed new regulations containing safety criteria, one covering the use of radioisotopes in radiographic operations, the other establishing standards for the shipment of irradiated fuel elements.

168. In the field of power and test reactors, we published last summer a Notice of Proposed Rule Making to prescribe factors considered in site evaluation. The proposed regulations were the result of considerable staff study and consultation with the Advisory Committee on Reactor Safeguards. Comments and suggestions were invited on the site factors, and on possible development of definitive site criteria, which might be incorporated in the Commission's regulations. A substantial number of comments indicated that the guidance intended by the proposed regulation is desirable. Many stated, however, that quantitative site criteria should not be prescribed by regulation at this time because the reactor industry is new and the factors associated with siting too variable.

169. The complexities of the problem of site criteria, and its interrelation with problems of design, containment, and operation, are becoming increasingly evident, and our study of criteria on all the major aspects of reactor safety has recently been expanded. With the cooperation of the Advisory Committee on Reactor Safeguards, the Commission established a special working group, in which experts from industrial organizations are participating, to examine the present status and future course in the program to develop detailed criteria and other tools useful in the safety evaluation of reactor projects.

CONTRACT ACTIVITIES

170. During 1959 the contract activity of the Commission exceeded in terms of dollar volume of contract commitments every previous year except the peak year of facility expansion that followed the Korean emergency.

171. In recognition of the important role of its contract program, the Commission late in 1959 established as part of the General Manager's Office, the Office of Contract Policy. The Director of this new Office is John R. Moore, who brings to this post 9 years' experience at our Oak Ridge Operations Office where he served both as principal contract negotiator and as Chairman of the Contractor Selection Board.

172. The Office of Contract Policy consolidates review and formulation of contract policy. We look to this Office to provide a focal point for assistance to the General Manager, headquarters and field staff on major contract policy matters, such as contractor selection and fixed-fee schedules. Establishment of this Office will not impair the authority of program divisions and managers of operations to negotiate and administer contracts.

173. Additional authority has been decentralized to the field in the reactor development program. Technical and contract administration responsibilities have been assigned to specific offices by reactor concept. For example, the Oak Ridge Operations Office has been assigned administration of the gas-cooled reactors program as a primary responsibility. A related effort is to concentrate in a designated office responsibility for handling business matters relating to all Commission contractual activities with each major contractor.

174. Increased use is being made of master or task-type contracts. Under such contracts, one set of general terms or conditions applies uniformly to all Commission work placed with a company. Greater administrative efficiency is expected to result from these changes.

175. Further the Commission modified its policies to permit Managers of Operations to submit directly to the Comptroller General of the United States any cases arising from mistakes in bids prior to awards. We have modified our policies to permit Managers of Operations, without referral to headquarters, to make awards to small business concerns or contractors who will perform work in surplus labor areas at a differential of up to 12 percent over a low foreign bid.

176. During the year the Commission worked out with the Administrator of General Services the relationship of the recently issued Federal Procurement Regulations to the procurement authority contained in the Atomic Energy Act. It has been agreed that these regulations do not impair any authority contained in the Atomic Energy Act. The Commission will follow the regulations in all areas, except those in which the special nature of our programs require otherwise. In addition, essentially all AEC procurement policy will be published in the Federal Register.

177. As reported to the Joint Committee during the last session, appeals arising under "disputes" articles of contracts now are heard by a single hearing examiner instead of by the Advisry Board of Contract Appeals. Our experience indicates that the delays which have occurred have resulted primarily from the request of parties, not from the procedure. The time required for rendering a decision, after submission of briefs, has been cut to approximately 4 to 6 weeks from an average of 18 months under the Advisory Board System.

178. The Commission, on December 29, 1959, published in the Federal Register a complete revision of its rules of procedure governing contract appeals. This revision constitutes a practical formalization of the rules to insure that the issues of dispute are clearly defined, and to insure that all relevant evidence is made available. The latter is accomplished by providing for the use of subpenas and, where necessary, the use of the discovery process, such as taking of prehearing depositions.

179. Indemnifications under the Price-Anderson Act now has been extended to all major AEC installations where a substantial nuclear hazard is present. Commission licensees are steadily qualifying for coverage under the act under the procedures that have been established. We have now extended coverage to common rail carriers hauling Commission materials. A detailed report on this subject will be submitted to this committee by April 1, as required by the Price-Anderson Act.

180. Abroad, the Organization for European Cooperation, the International Atomic Energy Agency, and the European Atomic Energy Community, all are working toward conventions to cover public liability.

181. I mentioned last year that the Commission and the Department of Defense were seeking closer agreement on cost-reimbursement principles in view of the large number of contractors holding cost-type contracts with both agencies.

182. We are in general agreement; but there are three specific areas in which our policies will continue to to be somewhat different. These are (1) advertising, (2) bidding expenses, and (3) bonuses of a profit-sharing nature. Our basic reasons for continuing to hold these costs unallowable is that they are not, in our judgment, related closely enough to the performance of the contract work.

183. The Commission has modified its policy on depreciation to make allowable amounts recognized as deductible for tax purposes by the 1954 Internal Revenue Code. Treatment of privately financed basic research as an allowable cost is being given further study by the Commission.

184. We are continuing our vigorous support of our established policy that a fair proportion of total purchases and contracts for Commission programs shall be procured from small-business concerns.

185. Opportunity for the small business participation in prime contracts is not great, since an extremely large dollar volume of these commitments is for the management and operation of Commission-owned production facilities and laboratories. Because of the magnitude of these operations, small business is not able to participate to a significant extent.

186. However, our prime contractors work actively to use small business for subcontracting in various ways. Typical of the methods used are:

1. Publicizing and explaining purchase requirements at industrial opportunity meetings sponsored by the Small Business Administration and others;
2. Grouping of items in invitations to bid as to both category and quantity to afford small business maximum opportunity to compete; and
3. Working with the Small Business Administration to assure inclusion on bidders' lists of a maximum number of qualified small-business firms.

187. Small business received an increased share of the total dollar value of Commission subcontract awards during the fiscal year ended June 30, 1959; totaling $220.5 million or 41.6 percent of $530.3 million total subcontract awards. By comparison, the small-business share the previous 12 months was 39.3 percent and for the 9-year period, 1951–59, the average share was 38.7 percent. At the prime contract level, the small-business share increased 18 percent. Total prime contract awards to small business amounted to $144.5 million for fiscal 1959, compared with $102.8 million for 1958, and an average of $78.5 million for the 9-year period 1951–59.

PATENTS

188. A number of amendments to the Atomic Energy Act affecting patents in the atomic energy field were proposed at the last session of the Congress. Congress extended section 153h of the Atomic Energy Act, permitting compulsory licensing of patent applications filed up to and including September 1, 1964. The Commission's conclusions and recommendations concerning the pending amendments, resulting from a review of its patent policies, were presented to this committee in April 1959.

189. We have recently had the experience of a large company in the heat exchanger business refusing to continue on a job for us at Argonne National Laboratory. They stated that the Commission's strict construction of section 152 pertaining to patent rights on work done "in connection with" any contract with the Commission was burdensome to the point that they could not afford to do the job. The pending amendments would eliminate this type of problem.

190. In the field of patents generally, we have been conferring with industry with respect to some complaints that we have been somewhat overreaching in acquiring rights in private background patents. We recognize that we should not insist upon such rights unless we have a need for them to carry out the purposes of the act. We also recognize that background rights to patents

acquired at private expense must not be taken from the private owner without some form of compensation—either as royalties or in the form of direct or indirect benefits to the owner under the contract.

191. The reason for obtaining background patent rights, of course, is to insure that the fruits of atomic energy research and development financed by public funds can be made available to American industry.

FUEL SUPPLY

192. The Commission's receipts of uranium concentrates from all sources under its various domestic and foreign arrangements, as projected over the next 3 years, exceed the Nation's estimated requirements to meet its weapons and power programs. The Commission has continued its efforts to bring supplies closer to a balance with requirements by arranging for deferred delivery of domestic and Canadian concentrates.

193. The Commission's contracts provide for a firm schedule of deliveries within the time period covered by each contract. We are not reneging on those contracts. In the United States, we are negotiating with producers to arrange postponement to the 1962–66 period of portions of deliveries scheduled for 1960–62. In some cases this involved deferrals under contracts that already extend to 1966; in other cases, deferrals are being arranged in negotiated renewals of contracts that would expire at a date earlier than 1966. These negotiations do not reduce the quantities of ore the mills buy from independent ore producers, but result in limiting production in the pre-1962 period of ores owned or controlled by the milling companies.

194. The Canadian contracts also call for a firm schedule of deliveries. They are due to expire in 1962 and 1963, and provide options under which the Commission may renew the contracts for additional periods of time. We have notified the Canadian Government that we would not exercise any of these options. The Commission and the Canadian Government reached an agreement which permits postponing some deliveries presently scheduled before 1962 or 1963 to a period beyond the expiration date of existing contracts; that is, in the 1962–66 period. The total to be delivered over the longer period will not exceed the amount scheduled under the original contracts.

195. In keeping with its limited domestic expansion program announced April 2, 1958, of providing an ore market in certain areas which had reserves, but had inadequate market, agreements were reached in 1959 for an additional 1,560-tons-per-day capacity for the central Wyoming area and the installation of a 200-ton-per-day mill in the Colorado Front Range. Further additions in these areas are not presently contemplated.

196. No agreements have been reached for southeast Texas, Nevada, and North Dakota-South Dakota lignite areas.

197. Other aspects of the Commission's raw material program are covered in detail in the Commission's annual report.

CONCLUSION

198. Mr. Chairman, members of the committee, this concludes the Atomic Energy Commission's statement. Our written submission supplements our testimony.

199. We will be pleased to present any additional information the committee may wish. My colleagues on the Commission, the General Manager, and our principal staff are here to assist you.

(The exchange of correspondence referred to on p. 2 follows:)

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
Washington, D.C., February 26, 1960.

Gen. A. R. LUEDECKE,
General Manager, U.S. Atomic Energy Commission, Washington, D.C.

DEAR GENERAL LUEDECKE: This will confirm Senator Anderson's request that the Commission provide written answers for the record to the four questions and comments set forth in his opening statements on February 16 at the 202

hearings on the state of the atomic industry. A copy of this statement is attached.

With respect to No. 3, relating to the cost of the program, arrangements have been made, as you know, with the Commission staff to obtain a more detailed explanation and comparison of the costs of the projected 10-year program.

In addition to these four matters, it would also be helpful for the Commission to provide answers to the following additional questions which arose during the hearings:

1. Would it be feasible and reasonable to move up the schedule of certain prototype and commercial-size plants in the projected 10-year program? It is noted that in some cases more than 1 year's operation is assumed before design of the next plant is contemplated for that particular concept. Would it not be possible to proceed with design of the next plant at about the time that research results begin coming in during the first year of operation? What effect would this have on your schedule? What general increases in cost, if any, would this entail?

2. Despite Commission comments to the contrary, most of the technical press have interpreted the AEC 10-year program to mean that greater emphasis will be given to the development, and particularly the hardware aspects, of the already established reactor concepts; namely, pressurized water, boiling water, and organic reactors. Please indicate the relative emphasis being given to these concepts in relation to the other less developed concepts.

3. It has been claimed that the Commission's 10-year program does not provide adequate emphasis for the development of economic small- and medium-size atomic power plants. Please prepare a statement on this question.

It would be appreciated if we could have the statements by March 5.

Sincerely yours,

JAMES T. RAMEY, *Executive Director.*

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., March 7, 1960.

Hon. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Congress of the United States.

DEAR SENATOR ANDERSON: This is in answer to Mr. Ramey's letter of February 26, 1960, to the General Manager, requesting replies to four questions raised in your opening statement at the 202 hearings, and to three additional questions set forth in the February 26 letter.

1. Question. There is a big gap in prototype construction with no starts from now until fiscal 1962. What is going to happen to our atomic equipment industry during this 2½-year period?

Answer. The development of a reactor concept to the power reactor stage is best accomplished by an orderly progression of technology—research and development; design, construction, and operation of one or more reactor experiments; design, construction, and operation of an experimental reactor plant; and design, construction, and operation of a prototype plant. Since the evolution of the program now has led to the stage of initiating construction of several prototypes and we are yet to gain operating data from these plants, it is logical that there will be periods of time during which no new prototype construction projects will be initiated.

However, the atomic equipment companies will be delivering equipment to the present AEC projects, including those in the national laboratories, and, we hope, to privately financed projects. The programs in the nuclear technology field and the series of proposed reactor experiments will also provide a substantial market for these services and equipment. Commencement of civilian prototype projects is not the only index of health or activity on the part of the industry.

We believe that it is important to have a planned, orderly program for the development of power reactors with the design of each new prototype soundly based on the results of the research and development and the operating experience gained from the reactors which preceded it.

2. Question. What effect will the failure of the Euratom program have upon the domestic atomic equipment industry? Should consideration be given to allotting to our domestic program some of the funds which would have come into the international program?

Answer. The lack of firm proposals under the joint U.S.-Euratom program for construction, by the end of 1963, of power reactors, other than the Senn project, is disappointing to us and to the U.S.-Euratom industry. The Euratom program, however, was never advanced or justified as a substitute for the U.S. domestic program; it was considered, rather, as a useful bonus to the domestic industry. Furthermore, you are well aware that the many licensing and other cooperative arrangements entered into by U.S. industry with European firms since the inception of the program undoubtedly would have led to much of the physical work being done in European factories.

Aside from the loss of possible business, the expected experience which would have resulted from the design engineering, fabrication, construction, and operation of the plants which would have been built will not be realized. This experience, while not an essential part of the U.S. development program, would have been useful as a supplement to that being obtained in the United States.

Of the incentives involving the expenditure of U.S. funds provided under the joint U.S.-Euratom program, the one which first comes to mind for possible application to the domestic program in the joint research and development program. However, at the time the Commission formulated its 10-year program for civilian reactor development, the fact that the scale of Euratom reactor program would be reduced was known, and due consideration was given to this factor in planning the domestic program. The domestic program, as planned, is considered to be a sound and orderly means for achieving its objectives. Sufficient funds have been and will continue to be requested to assure that the objectives of the domestic program are met in a timely, logical manner.

In formulating future cooperation with Euratom as well as with other foreign groups, we will continue to plan these programs in light of the domestic research and development effort.

3. Question. A brief paragraph on the cost of the program is presented at the end of the Commission's statement on the civilian power program. The Joint Committee on Atomic Energy has requested a more detailed explanation of the cost. In the past the provisions of the cost projections have been extremely difficult to work out.

Answer. Arrangements have been made for the AEC staff to discuss this further with the Joint Committee on Atomic Energy during the week of March 7, 1960.

4. Question. What measures do you recommend to expedite our schedule on atomic projects? You publicly called attention to this problem and contrasted our method with the Russians.

Answer. While we should reconsider some of our methods, this does not imply that we can or should use the same methods used by the Russians. We must be certain, however, that within our structure we do things as expeditiously as possible.

Within the Commission we have been working on this problem and there are indications of progress. Our forward planning in the reactor development field is now more complete than in the past, and this fact will permit a faster start on authorized projects. We have established a system of top-level reviews by the Commission itself of the schedules for various steps of a project and, in turn, of the performance against these schedules. The beneficial effects of these steps is already being felt in part, but will be felt to even greater degree as the program proceeds.

The change resulting from our more complete forward planning is most significant. When the cooperative power program began, the initiative was with industry. AEC received proposals conceived by industry and then tried to fit them into an overall program or build an overall program around them. We now determine in advance the type of work we want to support and then

seek a cooperative venture for a particular project when that is the appropriate coure to follow. In so doing, in most cases, we are explicit about our resolve to complete the project and have full intention of proceeding on our own if cooperative projects do not prove practicable. This gives us an entirely different approach to the timing and scheduling of development work for the specific job or even of the design work, for example, on both of which we can proceed in advance of the cooperative arrangement if necessary to avoid delaying the project itself. This also makes it possible to incorporate draft contract terms in the invitations and reduce to some extent the time required to negotiate contractual agreements after the selection has been made.

Beyond these significant changes in approach, which are affecting and will continue to affect our ability to expedite schedules on particular projects, much further improvement is being achieved by identifying on a case-by-case basic specific items which are proving to be bottlenecks, taking steps to eliminate those bottlenecks for the particular project and adjusting our planning and scheduling for other projects accordingly. In this connection, we have had good cooperation from the staff of the Joint Committee when this process raised questions of interpretation of the rules under which the cooperative programs have been conducted and which were originally developed when our approach to cooperative projects was somewhat different. To date, we have found no need for a wholesale revision of the rules established for cooperative programs since many of the changes we can accomplish within our own internal AEC structure; others will require continued discussions on a case-by-case basis with the committee or its staff.

5. Question. Would it be feasible and reasonable to move up the schedule of certain prototype and commercial-size plants in the projected 10-year program? It is noted that in some cases more than 1 year's operation is assumed before design of the next plant is contemplated for that particular concept. Would it not be possible to proceed with design of the next plant at about the time that research results begin coming in during the first year of operation? What effect would this have on your schedule? What general increase in cost, if any, would this entail?

Answer. In planning a program for the development of nuclear power for the next 10 years we attempted to exercise our best judgment as to the time required for the various steps in developing each reactor concept. For a prototype to give useful information it should be constructed only after all of the necessary research and development is completed or can be projected to completion. Therefore, acceleration of the construction of a prototype to a point where the necessary research and development is not yet available would negate much of its usefulness.

The 10-year program as presented is a programmatic sequence of technical events and is not intended to be a series of construction schedules. It was necessary, in conducting this study, to project time intervals for each of the events, including prototype construction, although it was recognized that the intervals may vary with individual concepts and with the rate of progress of each program.

To the extent that projections of this nature have a margin of error, there may be cases in which these estimates have been pessimistic; when the results of the research and development program show this to be the case, we can and will accelerate the schedule. There also probably will be cases in which our estimates prove to have been overly optimistic and, therefore, some delays in the initiation of prototype construction may prove inevitable.

6. Question. Despite Commission comments to the contrary, most of the technical press have interpreted the AEC 10-year program to mean that greater emphasis will be given to the development, and particularly the hardware aspects, of the already established reactor concepts; namely, pressurized water, boiling water, and organic reactors. Please indicate the relative emphasis being given to these concepts in relation to the other less developed concepts.

Answer. The following table gives the estimated cost of the civilian power reactor program with tentative allocation to research and development and prototypes with a preliminary distribution by concepts:

Estimated cost of civilian power reactor program for period 1961–69, as outlined in Part IV, with tentative allocation to research and development and prototypes and preliminary distribution by concepts

[In millions of dollars]

	Research and development	Prototypes		Total
		Number	Amount	
Nuclear technology:				
General research and development	450			
Support facilities	195			
Total nuclear technology	645			645
Reactor development—by concepts:				
Pressurized water	70	3	70	140
Boiling water	50	2	45	95
Nuclear superheat	50	1	30	80
Organic cooled	70	1	30	100
Subtotal light water and organic	240	7	175	415
Sodium cooled, fast	140	1	30	170
Sodium cooled, thermal	25	1	30	55
Gas cooled, enriched	100	1	30	130
Heavy water	55			55
Aqueous homogeneous—research and development	65	1	20	100
1. Reactor experiment	15			
New concepts—research and development	45	3	80	140
5 experimental reactors	15			
Subtotal—other concepts	460	7	190	650
Total—reactor development by concepts	700	14	365	1,065
Grand total	1,345	14	365	[1] 1,710

[1] Minimum cost to meet objectives of program. Does not attempt to forecast distribution of this cost between Government and industry.

Does not include cost of projects currently authorized or cost of research and development, additional prototypes or full scale plants which may be initiated by private industry.

Distribution by concepts is a planning estimate, and actual cost may be more or less for any particular concept.

Annual cost may be higher or lower than the average of $200 million per year.

This table indicates that during the 10-year period the number of prototypes for the longer range concepts will be the same as the number of prototypes for the concepts which are in a more advanced state of development. The proposed distribution of funds shows a considerably larger overall effort on the longer range concepts, particularly when the proposed costs for nuclear technology are added, since the primary emphasis in nuclear technology is applicable to longer range concepts.

It should be recognized that during the early years of the 10-year period, the emphasis in the water and organic reactor concepts will be on hardware since our knowledge of these systems is such that a program of carefully planned prototype construction and operation can be reasonably expected to meet the objective of economic nuclear power in certain high cost areas in the United States in the relatively near future. The primary emphasis on the longer range concepts over the next few years is on research and development programs which will give us the information needed to bring these concepts to the point where extensive construction is justified to meet the longer range objective of achievement of economic nuclear power over broader areas of the United States.

7. Question. It has been claimed that the Commission's 10-year program does not provide adequate emphasis for the development of economic small and medium size atomic powerplants.

Answer. The development of technology must be distinguished from the engineering task of adapting technology to a particular size of plant, whether it be large or small. Our primary aim is to develop nuclear power technology to the

point where it is competitive with the technology used for powerplants utilizing fossil fuels in both large and small plants, and a large fraction of the effort outlined in our 10-year program will be equally applicable to small as well as to large plants. Then the technology can be adapted to particular plant size requirements.

In addition to the general work, and to the prototype construction program, we now have four small powerplants in the final planning or construction stage which will demonstrate the adaptability to small plants of present technology in the boiling water, pressurized water and organic systems. These are the Elk River Plant (using the boiling-water system with a conventional superheater), the Bonus project (also utilizing a boiling-water reactor but with a nuclear superheater), the Small Size Nuclear Powerplant (which will use pressurized water technology) and the Piqua Plant (incorporating the organic system). As we pointed out in our 10-year program presentation, we propose a continuing effort in this field, and we anticipate that during the next few years several additional small reactor demonstration units will be constructed.

We will be glad to discuss these questions with you further during the authorization hearings or at such other time as you may desire.

Sincerely yours,

(S) JOHN F. FLOBERG, *Acting Chairman.*

(Whereupon, at 5:20 p.m., Wednesday, February 17, 1960, the committee adjourned until 2 p.m., Thursday, February 18, 1960.)

52950—60——11

DEVELOPMENT, GROWTH, AND STATE OF THE ATOMIC ENERGY INDUSTRY

THURSDAY, FEBRUARY 18, 1960

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
Washington, D.C.

The committee met, pursuant to recess, at 2 p.m., in room P–63, the Capitol, Senator Clinton P. Anderson (chairman of the Joint Committee) presiding.

Present: Senators Anderson and Aiken; Representatives Holifield, Price, Aspinall, Van Zandt, and Hosmer.

Also present: James T. Ramey, executive director; John T. Conway, assistant director; David R. Toll, staff counsel; and George F. Murphy Jr., professional staff member.

Chairman ANDERSON. The committee will come to order.

This afternoon the Joint Committee is meeting to receive testimony from witnesses from industry on the development, growth, and state of the atomic energy industry.

Our first witness today is Mr. Frank McCune, of the General Electric Co. We are happy to have you with us again, Mr. McCune.

Will you please proceed?

STATEMENT OF FRANCIS K. McCUNE, VICE PRESIDENT, GENERAL ELECTRIC CO.

Mr. McCUNE. Senator Anderson, my name is Frank McCune, representing the General Electric Co. I have with me Mr. William Kennedy, who is counsel for the company's Atomic Products Division. I have a written statement. Shall I proceed to read it?

Chairman ANDERSON. Will you proceed, please?

Mr. McCUNE. It is a pleasure to respond again to your invitation to testify in the annual 202 hearings.

I would like to introduce my statement today with a brief description of our existing projects, with a word about our marketing efforts. The past 18 months have been technically the most productive in the history of our commercial atomic energy ventures.

DOMESTIC PROJECTS—DRESDEN

Construction of the world's largest single-unit, all nuclear power plant, the Dresden station, exhibit 1, was completed ahead of schedule and initial criticality was achieved on October 15, 1959. The start-up program has gone very well, with all nuclear results extremely close to our original calculations.

Dresden is the first large boiling-water reactor and the first designed and constructed in the United States with close attention to the principle of economic power generation. We expect to learn a great

deal from its startup and initial operation. Much valuable technical information is more readily obtainable at this time than after the reactor has been placed in full operation.

For this reason, we have planned an extensive period of critical testing and initial operation prior to the commencement of regular power operation. Among the points that we are very interested in is how much the plant may have been overdesigned for such things as stability, automatic shutdowns, and environmental radiation levels.

Testing was held up briefly by mechanical difficulties with the connection between the control rods and the drive mechanism, but these have been corrected without any major design modifications, and tests are proceeding toward full core loading. The results to date demonstrate continuous compliance with safety criteria and with AEC operating license requirements.

I might say we have completed two complete sets of critical tests since that time, and presently the reactor has 256 fuel elements in it and is still performing exactly in accordance with calculations.

Representative VAN ZANDT. Mr. McCune, for how long a period was the plant shut down?

Mr. MCCUNE. It has been out of actual testing around 6 weeks.

Representative VAN ZANDT. It was really not a mechanical failure. It was just a correction which had to be made?

Mr. MCCUNE. That is correct.

Representative VAN ZANDT. The need of this correction developed from experience?

Mr. MCCUNE. It is the kind of thing that we wish we had found first, but we did not. It is one of the first few things we have found that we did not catch first.

Chairman ANDERSON. I do not quite understand the answer that it was not a mechanical failure. I thought these were some sort of pins that held control rods that broke. That was not theoretical, was it?

Mr. MCCUNE. Let me go further into it.

Chairman ANDERSON. I have expressed myself on the reactor in Chicago many times, that I am heartily, enthusiastically in favor of it.

Mr. MCCUNE. It was a failure in the connection between the control drives and the control rod itself. The connection there is a pin which is designed so that if anything should stick in getting the control rods off, say, in a future maintenance operation, this pin is the place where it would shear off or come apart.

That pin was not strong enough and had to be replaced with a stronger connection. Actually, the stress on the pin was caused principally by variation in tolerances of the couplings, which is the thing you adjust while you assemble the reactor. That is an oversimplified statement, but it is pretty close to the story.

Chairman ANDERSON. Had the safeguards committee called attention to this possibility earlier?

Mr. MCCUNE. This has never affected the safety of the reactor. It would not affect it.

Chairman ANDERSON. I was not worrying about it. I was merely asking had the safeguards committee called attention to this?

Mr. MCCUNE. Not to my knowledge; no.[1]

[1] In hearings on Apr. 27, 1960, the Chairman and Vice Chairman of the Advisory Committee on Reactor Safeguards indicated that the ACRS had informed the AEC, at least, in the spring of 1959 of problems with respect to control rods in this reactor.

EXHIBIT I

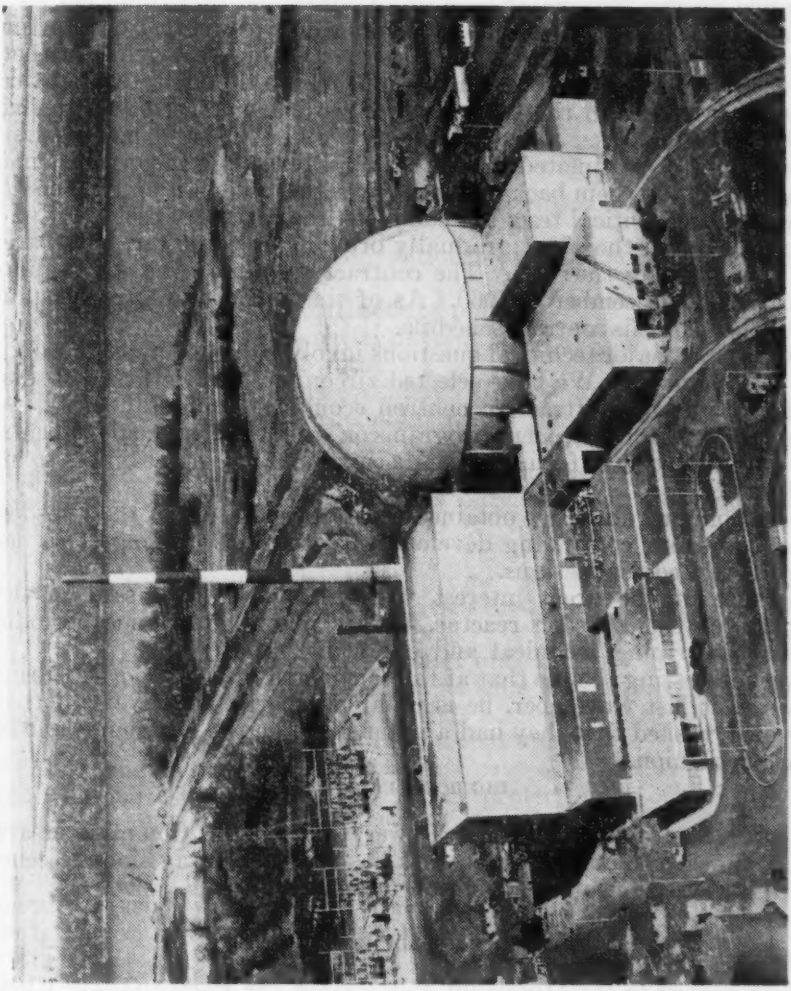


EXHIBIT 1.—Aerial view of the recently completed 180,000-kw. Dresden nuclear power station. Built by General Electric for the Commonwealth Edison Co. and the Nuclear Power Group, this station went critical on October 15, 1959, with regular operation scheduled for December 1960.

Representative VAN ZANDT. What about the cladding of the fuel elements?

Mr. MCCUNE. That has never held up the reactor.

Representative VAN ZANDT. In other words, that was more for perfection than anything else, was it not?

Mr. MCCUNE. That is right.

Representative VAN ZANDT. There was no failure there whatsoever?

Mr. MCCUNE. No. As a matter of fact, the fuel elements in the Dresden reactor have never been up to power and they could not have failed. But in the process of examining and testing all of the fuel rods which we had in the little Vallecitos reactor, we developed a better test. When we applied this to some of the tubing we found that there were cracks in the tubing which we had not been able to find with any other test. Since the tubing we had on hand had some of these cracks, we estimated the tubing we already put in probably had some so we took them back and went over the whole kit and kaboodle.

When these critical tests are complete, the reactor vessel head will be installed and the plant gradually brought up to power, with careful testing along the way. The contract schedule calls for regular operation by December 8, 1960. As of the moment, we are substantially ahead of this contract schedule.

One of our major technical questions involves the optimum cladding for fuel elements. We have selected zirconium for the first Dresden load because of its attractive neutron economy. Simultaneously, we have conducted development programs on stainless-steel-clad elements. We plan to obtain information on both zirconium and stainless-steel-clad fuel.

Based on the knowledge obtained from the operation of the Dresden reactor and our continuing development programs, we expect to develop advanced fuel designs.

Because of the great interest which has been expressed in the progress of the Dresden reactor, we are planning to issue periodic reports describing technical and operating progress.

It is interesting to note that at the conclusion of Professor Aleksandrov's visit last November, he is reliably reported to have said that they only wished that they had a plant just like the Dresden plant in the Soviet Union.

BIG ROCK PLANT

Negotiations with Consumer Power Co. and the Commission are still being carried out. Design work has been underway since December in anticipation of confirmation of contracts.

HUMBOLDT BAY

With regard to the Humboldt Bay station for Pacific Gas & Electric, our customer allowed sufficient time for development work, particularly with respect to containment and major progress has been made. Total station design is 25 percent complete, with the General Electric portion 50 percent complete. Orders have been placed for limiting components and the plant is proceeding as originally planned.

FOREIGN PROJECTS—RWE

The reactor which we are supplying to RWE, a large German power company, is well along, as indicated by exhibit 2. Civil construction

is about 90 percent complete and equipment installations about 40 percent. Startup is scheduled for the summer, continuing into the fall. The schedule date for regular operation is December 1960.

Senator AIKEN. May I inquire there, this plant is to be privately operated after completion?

Mr. MCCUNE. Yes.

Senator AIKEN. How is the cost of the plant divided? Who is paying for it?

Mr. MCCUNE. RWE Co. in Germany.

Senator AIKEN. Is it a private installation? Do they get any public funds from Germany?

Mr. MCCUNE. I cannot answer that.

Senator AIKEN. I beg your pardon?

Mr. MCCUNE. I do not know. I do not believe they do.

Senator AIKEN. How is it located in Germany? What would its competition be?

Mr. MCCUNE. It is located in the east-central portion of West Germany.

Senator AIKEN. Is it near conventional plants that it will compete with?

Mr. MCCUNE. This is a small reactor plant.

Senator AIKEN. What capacity is it?

Mr. MCCUNE. 12,500 kilowatts.

Senator AIKEN. And it is considered feasible and competitive?

Mr. MCCUNE. No. This is a plant which this power company decided to purchase in order to get going on their own atomic energy program and to learn about atomic energy plants.

Senator AIKEN. But it is a privately purchased and operated plant.

Mr. MCCUNE. That is right.

Senator AIKEN. That is all.

Mr. MCCUNE. Senn—The Senn project in Italy is on schedule. Exhibit 3 shows the actual state of construction. The date for completion of this project is October 31, 1963.

Representative VAN ZANDT. Mr. McCune, may we go back to the RWE reactor? What kind of arrangements do you have with those people concerning safety and so forth?

Mr. MCCUNE. I am glad you brought that up.

The Germans, as you know, have just passed a basic atomic energy act. It covers such matters as liability protection, I believe inspection.

As we sit here this moment, we are waiting for the translation or we are obtaining a translation of the German act from our German counsel in terms which our lawyers can understand in connection with our law to see how this act applies.

But both sides on this job went ahead on the basis that this kind of a situation would be straightened out, and our contract calls for us not to ship the fuel unless it is.

Senator AIKEN. I was just wondering what is the estimated cost of production in this plant.

Mr. MCCUNE. Power cost?

Senator AIKEN. Yes.

Mr. MCCUNE. I could not tell you.

Senator AIKEN. You do not know how it will compare with the conventional plant?

EXHIBIT II

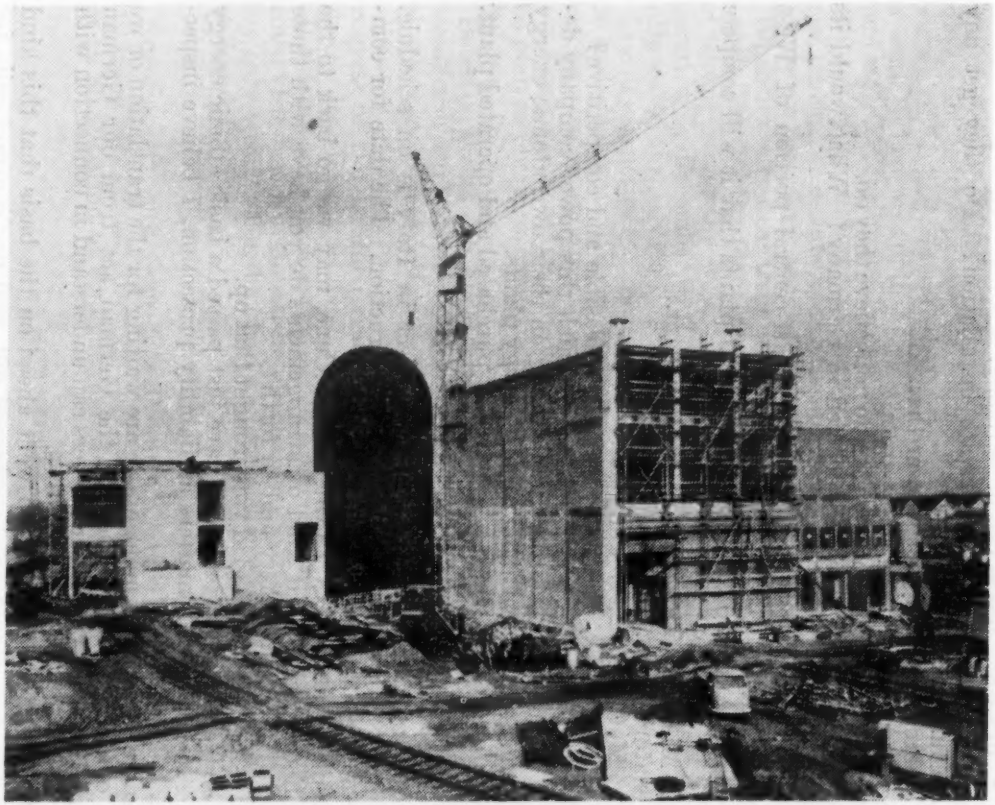


EXHIBIT 2.—Recent construction photo of the RWE plant which the General Electric is building for West Germany. Startup is scheduled for this summer and the plant is expected to be ready for turnover to its operators in December 1960.

EXHIBIT III

EXHIBIT 2.—Recent construction photo of the RWE plant which the General Electric is building for West Germany. Startup is scheduled for this summer and the plant is expected to be ready for turnover to its operators in December 1960.

EXHIBIT III

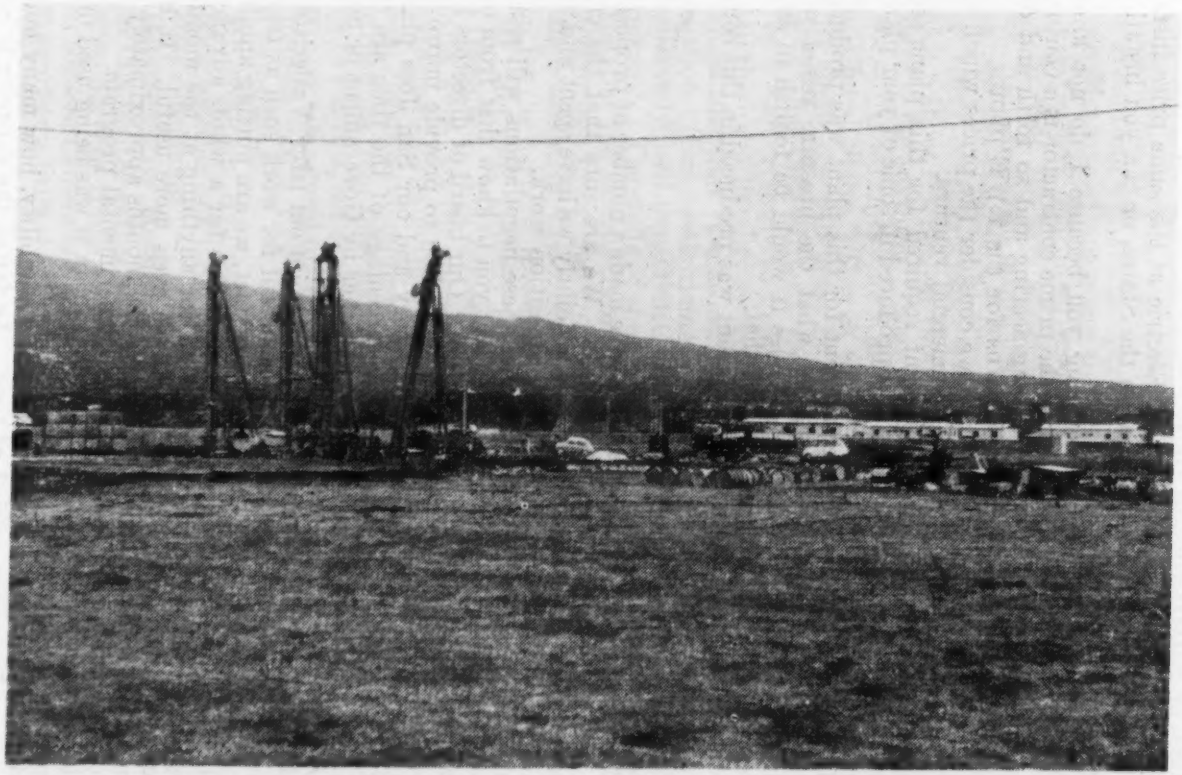


EXHIBIT 3.—Piles are now being driven for the foundation of the 150,000-kw. Senn plant which General Electric is building for Italy. Construction of this plant is scheduled for completion in late 1962 and startup planned for early 1963.

Mr. McCUNE. This particular RWE plant, without any question, will be more expensive than a conventional plant because this is a 12,500-kilowatt plant, and I would guess that RWE, which is the largest power company in Germany, I believe, must have at least 100,000- or 200,000-kilowatt conventionals on the lines.

Senator AIKEN. Would General Electric at the same price install the 12,500-kilowatt plant there as in the States, or can you install it cheaper in Germany?

Mr. McCUNE. I am not answering you because I do not know exactly. In this particular station, the prime contractor is a German company which is doing the civil engineering and so forth and obtaining the nuclear equipment from us for the RWE plant.

I think it is a fair statement that we consider the prices which we got on the equipment as a good commercial venture.

Senator AIKEN. Was the equipment required for this plant sent over from the United States or was it produced in some of your plants over there?

Mr. McCUNE. The nuclear equipment for this plant was produced in this country. I am not sure but what the pressure vessel was probably produced in Germany, because it would be foolish to ship such a thing across. I am certain of that.

Senator AIKEN. The nuclear equipment was produced in this country and shipped.

Mr. McCUNE. That is right.

Senator AIKEN. That is all.

Mr. McCUNE. As to the future, we have made a number of proposals for both large and prototype stations. We are sure that the customers in these cases are interested, and jointly we have spent and are spending substantial sums for this proposition work.

Obviously, we do not know whether these negotiations will result in orders for General Electric, but I want you to know that from our viewpoint we are confident of the future. Our board of directors has approved the investment of another $2 million to provide improved facilities both at our Vallecitos laboratory and our San Jose plant.

Representative VAN ZANDT. What percentage of the time are the facilities at Vallecitos being employed either by Government or non-Government?

Mr. McCUNE. At the moment, as I will point out later, Vallecitos is being remodeled to make it even more useful for work such as training and superheat tests. As a matter of fact, we are putting another million dollars of our money into that reactor for a whole advanced program. So it is not being employed for anything at the moment except for the remodeling, so it will be even more useful. It has been available, I believe, over the past some months approximately 80 percent or more, even thought it is an experimental program.

Representative VAN ZANDT. Does that mean it was being used only 20 percent of capacity?

Mr. McCUNE. No. I was talking of availability, how many hours it has run in a given period of time. As far as the capacity is concerned, the capacity of the reactor at Vallecitos is much greater than the capacity of the turbines which are installed there. The turbine is good for about 5,000 kilowatts. The reactor can produce much more steam than that, and that steam is put through a cooling tower

and condensed and lost, because as we have increased the rating of the reactor substantially we have not seen any reason to put in more turbines to use the steam.

Representative VAN ZANDT. Could we go back to the Senn reactor in Italy?

Mr. MCCUNE. Yes.

Representative VAN ZANDT. Will you give us an explanation how you are dealing with the safety requirements?

Mr. MCCUNE. I am going to give you a statement on this thing. One of the most difficult situations with regard to foreign contracts is exactly what you save said. I have pointed this out from time to time. An American manufacturer quoting abroad today has an option, for example, to say that the customer will be responsible for any safety considerations. This he will not do because he knows nothing about the nuclear thing. You can say that we would be responsible for anything. That would certainly be putting our neck in a noose. One can say we will design this to standards acceptable in the United States. This is essentially what we are saying, but I must admit one will never be able to prove it because the only way one can find what criteria are acceptable in the United States is to have a reactor ready to build in the United States. It will not be until there is a liability system and a regulatory system established in Europe that that framework will have caught up with the technical situation. This needs doing. In order for this to come about we desperately need that OEEC and Euratom drafts and regulations be processed. The staffs of these organizations have prepared good material, but the nations themselves, to the best of my knowledge, have not approved any of them.

Representative VAN ZANDT. Has any group entered into a convention for the purpose of considering the first draft?

Mr. MCCUNE. It is my recollection that the drafts were presented in December. You correct me if I am wrong, Mr. Kennedy. The drafts were last considered in December. At that time they were considered by the government representatives of the member states. These government representatives being those men who obtain their instructions from their national government, and vote. I don't know how to put this, but at that time the drafts were not approved nor was anything else agreed to, to the best of my knowledge.

Representative VAN ZANDT. Probably you could call it a preliminary approach.

Mr. MCCUNE. As I pointed out, and as I know you agree, the actual getting together of a large number of nations on a problem of this kind is time consuming.

Representative HOSMER. If the gentleman would yield, you went into this matter rather thoroughly in the hearings last year. I am just wondering if the experience in this intervening year indicates that some settlement is coming along at about the pace you anticipated last year, or a little slower or faster.

Mr. MCCUNE. Speaking as an individual, I had hopes that this December meeting would be productive of agreement which, of course, would have to go back to the member nations for ratification and implementation. So to that extent I am a little bit disappointed.

Representative HOSMER. With relation to our expectations of last year rather than your hopes of last year, there is some disappointment; is that correct?

Mr. MCCUNE. It has been my feeling that this particular area, the area of governmental regulation, protection, liability, and so forth, greatly lagged behind our hopes for American participation in European programs. This might well prove to be the limiting factor.

Representative HOSMER. You still have that effective clause in the Senn contract where you don't deliver until this third-party liability matter is settled; is that correct?

Mr. MCCUNE. In such areas as we are going forward, to be specific about it, two things have to be done. One, you have to be sure that both the manufacturer and your customer really believe that certain things are necessary before you go ahead with it. Second, you write the best contract you can to effectuate that.

Representative HOSMER. Specifically with relation to Senn, do you still have a clause in your contract there?

Mr. MCCUNE. We won't complete the Senn project nor will they operate it without adequate legislation being on the books.

Representative HOSMER. That is still your position?

Mr. MCCUNE. That is still our position.

Representative HOSMER. Practically and philosophically.

Mr. MCCUNE. That is right. Beyond that it is our opinion that both the Senn group and ours have essentially the same ideas as to what adequate legislation is. Without that you would not proceed with anything.

Representative HOSMER. That would have to come in by 1963.

Mr. MCCUNE. It has to come in by 1963 or before; that is correct.

Chairman ANDERSON. What sort of legislation did you say had to be on the books?

Mr. MCCUNE. Legislation that covers such matters as inspection, licensing, if any.

Chairman ANDERSON. Not liability?

Mr. MCCUNE. Safety, liability, the whole gamut. Methods of transporting the fuel, what restrictions are going to be on it; all of this has to be in place before you can really operate anything.

Representative VAN ZANDT. Mr. McCune, suppose the West German Government wrote into law a series of protections along the lines that you speak of, would you feel or the corporation you represent be satisfied to the extent they would close a deal with the West German Government to operate a reactor?

Mr. MCCUNE. I think I can say this accurately. I don't know the name, but let us say the equivalent of our Atomic Energy Commission in Germany, intended to obtain a law such that German or American or other manufacturers could proceed with confidence in West Germany. They have publicly said that they believe the law they have obtained is such that this is the case. At the moment, I can't say yes or no because we are in the process of obtaining—our company is—opinions of German counsel as to just exactly what this new law means. These are on their way and in a short time I could answer that. Maybe in a month or 2 months. I don't know.

Representative VAN ZANDT. I was thinking of the liability.

Mr. McCUNE. It was their intent to cover the whole thing for their country. Whether they have done so or not I cannot tell you without these opinions.

Representative VAN ZANDT. In the discussion of this matter last year, you remember we developed this situation. You have so many countries over there and an accident in one country would affect the people in the other. Therefore, the liability not alone affects one country but the surrounding countries also.

Mr. McCUNE. That is right. For this reason the basic solution, I think, to the problem really requires the formulation—and this work is well along—of something like the OEEC convention, or the Euratom convention, which has been written on the present supposition that the OEEC convention would be adopted. This in turn, I believe, needs to be followed by an overall international or world type of convention, and work has been done on such a thing.

I would hope that all the force of the U.S. Government would be used to obtain as good treatment for American manufacturers abroad as you have furnished for foreign manufacturers here.

Mr. RAMEY. Would you want the Price-Anderson Act extended abroad?

Mr. McCUNE. No. I don't believe there is anything that Congress can do in the way of legislation which solves this problem. All I have said was that I hoped that the force and influence of the U.S. Government would be used to see that abroad the conditions under which American manufacturers operate are as good as the conditions which foreign manufacturers would have imposed upon them if they operate here. It seems to me that is a fair request.

Representative VAN ZANDT. A little reciprocity.

Chairman ANDERSON. That would also involve your willingness to have the same test applied to your reactors by each foreign government that our Government would apply to a foreign reactor?

Mr. McCUNE. That is right. This is necessary.

Chairman ANDERSON. How do the Senn reactor fuel guarantees compare with the guarantees stipulated in the Euratom agreement?

Mr. McCUNE. If you want that in detail, I would have to give you written comments, but it is my understanding that the customer is just about as happy with the guarantees he has on fuel from us as any other guarantees. One reason for applying under the Euratom is the assurance of obtaining the fuel which goes with Euratom.

Chairman ANDERSON. The Atomic Energy Commission in its testimony at paragraph 114 said that we have approved the Senn proposal recommended to us by the U.S.-Euratom joint reactor board as a generally satisfactory project and as an acceptable basis for development of such necessary subordinate arrangements as the Euratom-Senn contract, the fuel-cycle guarantee contract, and the U.S. fuel supply plutonium purchasing and reprocessing contract.

There was in the original legislation a provision about fuel guarantees. Are the fuel guarantees in the Senn contracts comparable to those provided in the Euratom legislation?

Mr. McCUNE. The answer is that the guarantees which we gave Senn are comparable.

Chairman ANDERSON. Is not the Senn program now under Euratom?

Mr. McCUNE. They have applied to be under Euratom; yes. Your real question is, "why?", I presume, and I think the real answer is, That Euratom or being included in Euratom to their mind is an excellent guarantee of the continued availability of enriched uranium 235.

Mr. RAMEY. And the deferred-payment plan?

Mr. McCUNE. As distinct from the fabricated fuel.

Chairman ANDERSON. Of course, they take title to it for 10 years without interest.

Mr. McCUNE. I think that is the drawing card, not whether the manufacturer would guarantee them the life on the fuel. That is what I am trying to say. Really, I suppose, the customer should speak for himself.

Chairman ANDERSON. Shall we go to the top of page 6?

THE AEC'S 10-YEAR PROGRAM

Mr. McCUNE. I cannot commend too highly the spirit and the effort evident in the Commission's recent evaluation of the potential of each development. I say that with the utmost sincerity. Naturally, many of the conclusions are based on an engineering judgment and I would expect no single person to agree with all of the conclusions. We hope that the following comments will be found constructive.

We believe that boiling water is the most promising approach to early attainment of economic nuclear power. This, however, is a matter not for argument but for demonstration.

We are, of course, continuously studying other approaches and have made specific recommendations to the Commission based on these studies. We have recommended to the Commission that our work for them on the sodium graphite modular reactor should not be extended. On the other hand, we have done some promising work on fast oxide breeders and are hopeful of support for a continued effort. Likewise, it is our opinion that the gas-cooled system has sufficient potential to justify further work, particularly in the materials area, such as high-temperature moderators and fuel.

We are not able to conclude that homogeneous reactors could be made economical even though the major technical problems, particularly those affecting dependability and safety may be solved. Hence, I have little enthusiasm for the development.

Work on a prototype heavy-water reactor is being done in Canada. I understand that the Canadian Government considers the design appropriate in light of the circumstances there. Our studies have not shown that this type is likely to be economical under conditions in this country.

We agree with the Commission's statements on nuclear superheat as an important development. To the best of my knowledge, nuclear superheat has been accomplished only on an experimental scale, and then only in two places: in the Russian reactor at Obninsk and our Vallecitos reactor. Substantially more experimental work will be productive, and this is one of the reasons that our Vallecitos reactor is being modified at an added cost of approximately $1 million.

I fully agree with the Commission's program for a thorough evaluation before going beyond the conception and first analysis stage.

As the Commission's description of the program makes clear, it will continue to be developed by the Commission and industry working together. Its success will require the use of techniques by which a private company can simultaneously conduct Government and private activities.

Assuming that the nature of a particular program is such as to justify the expenditure of public funds, the Government's concern in choosing a contractor to do the work should be primarily whether the contractor has the technical competence to give the Government the best results for its expenditures. The mere fact that a program whose results would benefit the industry as a whole, would also benefit the company carrying on the work should not disqualify that company.

NUCLEAR MARITIME PROPULSION

Since reporting to you last year, we have completed for the AEC the preliminary design of a boiling-water system for a 60,000 deadweight-ton tanker. This has substantiated our belief that the direct cycle natural circulation boiling-water reactor is appropriate for marine application. Test work to confirm these calculations is underway.

Operating characteristics and cargo density determine that competitive power will first be realized on large high-speed, long-run tankers.

Progress is being made in developing international solutions for safety regulations and liability protection. This is on maritime. This work must be pushed vigorously if it is to keep pace with the progress in engineering.

AEC POLICY ON THE USE OF PRIVATE TEST REACTORS

The lack of sufficient load for our test reactor has continued to be a major problem for General Electric.

In the middle of negotiations between the AEC and ourselves for the use of this space, it may seem out of place to discuss this matter; however, our experience does relate to problems which you have considered important.

The first has to do with the need for test reactor space. Two years of intensive effort to sell such space has indicated to us that the demand is not nearly as great as has frequently been assumed.

Secondly, it is important that the Commission should take necessary administrative action so that effective use is made of private test reactors for irradiation programs within or supported by the AEC.

ADMINISTRATION OF THE FACILITY LICENSING SYSTEM

One of the major problems which will have to be faced by the growing nuclear power industry is the facility licensing system.

It should be possible to find ways to attain the objectives desired without imposing unreasonable burdens on industry.

Anyone familiar with the present licensing procedures knows that if we are to achieve broad usage of competitive atomic power, the present licensing system must be simplified. We are encouraged by the Commission's willingness to refine and improve its procedures and

to consider industry's suggestions. To this end, we, in industry, must do a better job than we have to date in developing specific constructive proposals.

Additionally, we believe that a request by you for comments on this point each year in your 202 hearings will insure that timely legislative action will be taken if it is required.

Finally, we recommend that except in the case where national defense is of paramount interest, all reactor facilities should be required by law to go through the same licensing procedures as privately owned facilities. The public is entitled to sure and open knowledge of the procedures employed.

Chairman ANDERSON. Does that refer to power reactors for the development of electric current or does that apply to Hanford and Oak Ridge and Savannah River?

Mr. MCCUNE. I should explain this. I said except in the case where national defense is of paramount interest. It would seem to me that in the case of a Hanford or a submarine that national defense is a paramount interest and you would not want a lot of open documents. If you rule those out, if you are building a prototype reactor for power production, it would seem to me it would be desirable to go through the same licensing procedure whether it is publicly or privately owned.

Chairman ANDERSON. Do they not do that as a matter of practice? On the REA cooperatives where the Government owns the reactor have they not gone through precisely the same operations as with the private reactors?

Mr. MCCUNE. As far as the REA is concerned, this is correct. As a matter of practice they are doing it.

Chairman ANDERSON. Do you know any others that the Government is building?

Mr. MCCUNE. I am quite sure, for example, that the plutonium recycle reactor which we are building for the Commission at Hanford is not going through the same licensing procedure as though we owned it.

Chairman ANDERSON. But it is not generating any electricity, is it?

Mr. MCCUNE. It doesn't seem to me it makes a difference if it is generating electricity or not. The licensing procedure does not apply only to reactors which produce electricity. It applies to the whole range of production and utilization facilities.

Chairman ANDERSON. I thought we were eliminating those that dealt with national defense. This one deals with national defense.

Mr. MCCUNE. No, not the plutonium-recycle reactor. I think the more reactors that go through the licensing procedure the faster we can go from a situation in which each has to be considered without any real rules, to a situation in which certain rules and practices can be established and we can get more from the individual examination to the building code type of situation.

Chairman ANDERSON. Let us go back to this plutonium recycle for just a minute. That is a test facility, is it not?

Mr. MCCUNE. That is correct.

Chairman ANDERSON. Do the private people in a test facility have to go through all the licensing provisions?

Mr. MCCUNE. Yes.

Chairman ANDERSON. And all you want to do is to get this plutonium recycling operation on the same basis as all others?

Mr. MCCUNE. That and all the other reactors like it on the same basis.

Chairman ANDERSON. Is it not the only one?

Mr. MCCUNE. No. The EBWR at Argonne. All of these reactors. They are all going to contribute very substantially to the body of knowledge from which you can work out standards which will make the licensing procedure a relatively accurate and simple procedure as compared to the long and detailed procedure which the first few have to go through inevitably.

Mr. RAMEY. If the Commission itself has to worry about the red-tape involved on their own experimental reactors you figure they will simplify it sooner, is that the idea?

Mr. MCCUNE. That could be. The more that go through the sooner we will arrive at a reasonable procedure. At least that is our opinion. I believe this personally very strongly.

AEC CONTRACT POLICIES

One aspect of vital industrial concern is the financial aspects of AEC contracting policies.

We believe it should be possible to employ a uniform set of cost principles applicable to all Government contracts, regardless of whether the procuring body is the Commission, the Department of Defense or some other agency.

We also believe that these principles should be applied consistently, regardless of the identity of the contracting agency. The present Commission practice on some contracts is to refuse reimbursement for substantial indirect costs. This practice has been defended on the ground that the fee paid to the contractor represents, in part, reimbursements of these costs. This creates the impression that there is a reasonable profit while, in fact, the so-called fees do little more than cover unreimbursed indirect costs.

The Commission is usually in a position to drive a very hard bargain with its contractors, yet, I question whether the long-range objectives of the country to develop a strong industry are really served by obtaining the hardest short-term contract.

Chairman ANDERSON. This relates to that section of the atomic energy work in which they don't allow money for advertising, business expenses, or bonuses.

Mr. MCCUNE. I don't think there is any Government agency which considers all advertising expense as a reimbursable cost.

Chairman ANDERSON. I didn't say all advertising expense. But the Department of Defense does allow a certain amount of advertising expense, business expense, and bonuses. The Atomic Energy Commission in paragraph 182 said:

> There are specific areas in which our policies will tend to be somewhat different. There are (1) advertising, (2) bidding expenses, and (3) bonuses of a profit-sharing nature. Our basic reasons continue to hold these costs unallowable because they are not in our judgment related closely to the performance of the contract work.

Mr. MCCUNE. My reason for believing that some of those which are not allowed should be allowed is that I believe they are closely related

to the performance of the contract work. This is a flat difference of opinion of which you are bound to have many in a program such as this.

THE ROLE OF THE COMMISSION LABORATORIES

I hope that the hearings tentatively planned on the subject of the role of Commission laboratories will result in more detailed and thoughtful consideration than can be given here. However, I believe that the McKinney Report on the Peaceful Uses of Atomic Energy pinpointed this important problem and suggested a policy. If the policy is other than that proposed, industry must understand this. In this connection, a report by the Atomic Industrial Forum entitled, "Atomic Research and Development—the Role of Industry" makes a useful contribution to the consideration of the basic issue.

That concludes my statement, gentlemen, and I wish to thank you for this opportunity to testify.

Chairman ANDERSON. You are familiar, are you not, with the chamber of commerce report? Were you not the subcommittee chairman on the committee on the commercial use of atomic energy?

Mr. MCCUNE. Senator, there has been confusion on two points. There is a Bureau of the Budget directive which has to do with the Federal Government performing work either in contractor-operated facilities or in facilities which are owned by the Government, and which it could obtain from industry. This is one series of problems. The chamber dealt with that. What I am talking about is what was in the McKinney report on the ultimate role of these very valuable, very important national laboratories as we engage in the transition. I am speaking of a transition to increased industrial participation. These are two different things.

Chairman ANDERSON. I am trying to relate it to the chamber of commerce report. You were the subcommittee chairman on the commercial use of atomic energy, subcommittee on Government competition with industry.

Mr. MCCUNE. Yes.

Chairman ANDERSON. One of the elements in that report was item 5, Fuel Element Fabrication, in which the suggestion is that fuel elements for the Hanford site are fabricated in Government facilities. This is a problem with which you are well acquainted because your own company is doing the fuel fabrication at Hanford.

Mr. MCCUNE. Yes, sir.

Chairman ANDERSON. I understand you feel this ought to be moved out of the Hanford facility and done in private industry?

Mr. MCCUNE. No.

Chairman ANDERSON. The following are some of these specific examples of where Government laboratories are competing.

Mr. MCCUNE. I am not trying to confuse. What I am trying to say is this. There is a large number of areas in which work is being done in Government-owned contractor facilities which might or might not be available from industry. One of these is the production of fuel for Hanford reactors, for example, which General Electric accomplishes in Government facilities. I think you will find that the chamber's letter said that these are typical areas which we believe should be examined under the policy issued by the Bureau of the Budget, and we

would hope that the Commission would set forth a public policy on these matters.

The General Electric Co. has not engaged, as far as I know, in any of these activities in which it felt that the work should be done otherwise. This includes the operation of the Aircraft Nuclear Propulsion Department or the Knolls Atomic Power Laboratory. We do believe that the policy of the Commission with respect to this kind of work should be made clear. This is the meat of the chamber's letter.

We have not said any of those are wrong. We have said all should be examined. These are borderline things and we would like to see a public policy set forth on them.

Chairman ANDERSON. I read in their report that this subcommittee was assigned the responsibility of compiling specific examples of Government competition with industry in the atomic energy program which the national chamber has received from its members:

> I am transmitting in this letter a listing of our subcommittee on Government competition with industry, and some of the specific examples of commercial industrial activities of the Government in the atomic energy program. We believe that a detailed evaluation of such cases is warranted under the terms of bulletin No. 60–2. We hope that a public statement of the results of such a review will be made as a contribution to clarifying Government policy in this area.

And the fuel element situation was one of them. One of the next things I could not help but notice was Sandia and Los Alamos design work for the Sandia test reactor. Also, Los Alamos experimental work on the thermionic cells to convert fission energy directly to electricity. I think that is the thermocouple, which some of the members are very much interested in.

What I am trying to find out is this: As chairman of this subcommittee, and head, I believe, of the forum, is this work on the thermocouple which is going on at Los Alamos, the sort of thing that should come out of Los Alamos and go into a privately owned laboratory?

Mr. MCCUNE. Is it the thermocouple or is it the thermionic? They call it the thermocouple.

Chairman ANDERSON. Isn't thermionic the same as a plasma thermocouple? If you say it is not, I will take your word for it.

Mr. MCCUNE. They are two names for the same thing; that is correct.

Chairman ANDERSON. It lists that work.

Mr. MCCUNE. The fact that it is in the list means that a reputable concern in the United States believes that had it been asked to undertake the work, it could have well done so, but was never given an opportunity nor asked whether it would be able to do the work. The work was simply assigned to a Government-owned laboratory to be done.

Chairman ANDERSON. Actually, I suppose private industry could have undertaken the job of making the atomic bomb.

Mr. MCCUNE. That is correct.

Chairman ANDERSON. I am just trying to find out if the committee, in listing these, thinks that these things are now projects that might move from Government laboratories to private industry.

Mr. MCCUNE. I will say that there is nothing in that list which some reputable company did not think it could have done. On the

other hand, I believe, and I think we put in our letter, the ultimate decision as to whether or not any of those specific things could profitably have been obtained from private industry is something you can determine only by going out for bids or offers. Neither we nor the Government can determine it without going through a procedure of this type.

Representative VAN ZANDT. Mr. McCune, give us in a few words the basis of the position taken by the chamber of commerce in their request that non-Government facilities be employed to carry on some of this work.

Mr. MCCUNE. I think this is getting a long way from the testimony of the General Electric Co., but you will have to separate these.

Representative VAN ZANDT. You speak for one of the non-Government groups concerned.

Mr. MCCUNE. Let me talk then, as I have been talking, with respect to a chamber of commerce committee. As industry grows, and I believe it is the deliberate intent of the Atomic Energy Act that industry shall grow, it is developing new and increased capabilities at all times. There was a time—or let me put it this way, let us go back to Hanford fuel. I specifically, as a businessman, would not want to contract to produce Hanford fuel for the production reactors. I would not. There may be a concern that would very much like to take the risk of doing this. I don't know. But this I do know, that the Hanford fuel was developed and placed in production at Hanford long before there was a fuel industry in place. Is it not reasonable to look at the overall fuel requirements of the Commission, rule out any in which defense is of paramount interest, because the Budget Bureau bulletin is quite clear if this is a matter of protecting our defense, it does not apply. Rule out any such things, and make a real determination of what the present capacity of the U.S. fuel industry is, in which there are 10, 15, or 16 reputable companies at the present time who could do these things, rather than continue automatically to put them back where they have always been. That is the way I look at that one. As a matter of fact, I said this in the committee meeting—this is not giving anything out of court—I don't make an apology for anything that the General Electric Co. is doing for the Commission, but I strongly feel that I would like it to be a matter of acknowledged public policy that we are doing it or I would like to get out of it.

Representative HOSMER. As I understand in connection with production matters, your answer is that private enterprise has the capability of doing it. Specifically, in relation to the chairman's question about the thermocouple, we are getting into a research type of activity there, as distinguished from a production activity; are we not?

Mr. MCCUNE. There are many areas in which research can be done better outside of Government-owned laboratories. There are many areas undoubtedly in which research can be done in Government-owned laboratories better than it can be done outside of them. I don't see that the fact that a thing is purely research is a criterion. The criterion is who can do it best.

Representative HOSMER. Isn't it going to take a Solomon to assess any particular line of research as to whether it can be best done privately or by Government?

Mr. MCCUNE. I think that the universities of this country would be deeply concerned if they felt that it was the policy of the Federal Government that, because something was research, it should be done in Government-owned facilities only. This has not been the practice of the Government. It has not been the practice of the Commission.

Representative HOSMER. I am not arguing for that.

Mr. MCCUNE. It is a difficult thing.

Representative HOSMER. My question was, Is it feasible or possible to take a specific research area and say this can best be done privately or this can best be done by the Government? It is not really possible, is it?

Mr. MCCUNE. I would take exception to that. It is not possible to do a perfect job any more than it is possible to do a perfect job of anything. On the other hand, the Research Division of the Commission has, I believe, very wisely placed a large amount of its research, and I believe an increasing amount of its basic research, outside of the Commission areas. They have literally hundreds of contracts with the universities of the United States. How they make their decisions I don't know, but I think their policy is sound, wise, and good.

Representative HOSMER. In this whole business of placing research, isn't there a matter of personality and personal enthusiasm of people who get into their field, originally generate the idea that there might be a fruitful area for research, and among their associates some are located in government, some in universities, and some in private places? It kind of filters around on that basis as much as any businesslike, cold evaluative basis. Isn't that true?

Mr. MCCUNE. That is entirely true. When you come to basic research, 99 percent, I should say as a judgment, is based on the people who would do the work, because basic research in essence is a very personal kind of contribution.

Representative HOSMER. In other words, it is not an easy problem.

Mr. MCCUNE. I have no question that it is a difficult proposition.

Representative VAN ZANDT. Mr. McCune, going back again to this chamber of commerce recommendation, did the committee establish percentagewise the facilities available and not being used?

Mr. MCCUNE. No. The chamber committee took the position that if a responsible member of industry thought that some business was being carried on within the Commission's facilities which could well be done elsewhere, that we would submit this as part of a list, not taking the stand that the Commission was wrong in doing this work, but asking that this be examined and some kind of policy be developed which would be clear.

Representative VAN ZANDT. Let me approach it another way. Did this chamber of commerce committee, when considering this problem, have knowledge of member companies who had a surplus of facilities that were not being used?

Mr. MCCUNE. The chamber committee did not approach the subject on the basis of whether there was a specific company whose facili-

ties were not loaded. They approached it on the basis of whether there was an industry in being and established which could do and was doing that kind of work or similar work, with the belief that where industrial facilities have been put in place over a period of time to do this type of thing, that the decision should be made as to whether or not they could compete within the terms of the Bureau of the Budget directive. This, as far as I know, cannot be determined by the chamber, or by anyone in the chamber, or by anyone else, except on the basis of putting such work out for offers and seeing what happens.

Representative VAN ZANDT. This is my final question.

Mr. MCCUNE. At the end of the offers the Government might say, "Look, we got offers from three incompetent people. We are not going to take it." This happens all the time. It might be true, or they might get some pretty good offers.

Representative VAN ZANDT. Assuming there are companies in this country who have surplus facilities.

Mr. MCCUNE. And would you add, or who would build facilities if the business were available.

Representative VAN ZANDT. I will accept that, but I am particularly concerned now about the companies having surplus facilities, what is going to happen to them unless the Government transfers some of this work to them from their laboratories.

Mr. MCCUNE. Let me put it this way. We have several conflicting objectives in the Atomic Energy Act. They are directly in conflict. One objective, and a sound objective—I am not criticizing—of the Atomic Energy Act is to have broad participation in the atomic energy industry. A second national objective is to have great speed. If you wish great speed, you take off all handicaps and you richly reward the front runner. If you want broad participation, you put a little extra weight on the fastest horse, and you get a lot of people in. We have a second basic conflicting objective, you might say, one which is to get the work done very rapidly, in which case probably the easiest way is to place the work directly under an existing budgeted contract procedure with a Government-owned facility, and another is to take the excess time required to go out and get bids. What I have been trying to say is that I believe we do have a developing industry. I believe that its capability is steadily increasing. I believe that one of the most difficult jobs which the Commissioners have, and it is only the Commissioners who can make these determinations, is the proper balance between breadth and speed and the proper balance between the work in the Government-owned facilities, and the kind of work which will accomplish the objective of a strong, broad industry, which will eventually take over the load. This is a difficult area, and we need patience, I agree. But it is one of the most difficult things in the world to be impatient enough to get action and to be patient enough to know that these are long difficult problems that no one is going to solve with a stroke of the pen or a stroke of the ax. The McKinney report really did a beautiful job on laying this particular area out. I think it is one of the pieces they can really be proud of.

Chairman ANDERSON. I think if we are to hear all of our witnesses this afternoon, we will probably have to excuse you, Mr. McCune, and ask Mr. Auchincloss of the Tracerlab to come forward, please.

STATEMENT OF S. S. AUCHINCLOSS, PRESIDENT AND CHAIRMAN OF THE BOARD OF DIRECTORS, TRACERLAB, INC.

Mr. AUCHINCLOSS. My name is Sam Auchincloss and I am president and chairman of the board of Tracerlab. Thank you very much, Senator Anderson, for asking me to appear again before the Joint Committee. I have a statement to read.

I am indeed pleased to have been invited to testify before this committee on the subject of industrial applications of radioisotopes. It is my belief, and the belief of many of my associates, that industrial applications of radioisotopes stand before us today as a promise unfulfilled.

My purpose in appearing before you, therefore, is to direct your attention to the relative lack of progress in this field and to suggest that the committee's influence be directed toward establishment of a more comprehensive and vigorous program to increase industrial applications of radioisotopes.

Consider the two major peaceful areas in which radioisotopes are currently employed in science and industry, and compare the progress which has been made in each.

In the field of scientific research, the use of radioisotopes and the "tracer" technique has placed within our grasp the keys to an understanding of life itself. I have heard the opinion expressed that prior to the availability of low-cost radioisotopes, a point of diminishing returns had been reached in many areas of basic scientific and medical research.

It appeared that the time and money required were increasing exponentially and that the processes under investigation were so hopelessly complex that many research workers despaired of ever completely understanding them.

This situation is no longer true. Greater amounts of money are being spent than ever before on basic research, and in every area of endeavor, knowledge is increasing with such rapidity that it is difficult even for experts to keep abreast. Today the Geiger tube and electronic scaler are found in virtually every important research laboratory, and their use is as common as that of the microscope or the analytical balance.

Regretfully, the situation that prevails in industry is quite different from that which prevails in scientific research. As of today, more than 14 years after the establishment of the Atomic Energy Commission, the radioisotope is a stranger in the great majority of our industrial plants. In fact, with the exception of beta ray thickness gaging, isotope radiography, and certain applications largely in the petroleum industry, there is little industrywide use of radioisotope applications.

The splendid successes which have been obtained in making tracer techniques standard procedures in the research laboratory are indicative of the overall competence and aggressiveness of the Commission in recognizing the potentials of radioisotope applications. Unfortunately, present statutory regulations have limited the field of industrial applications of radioisotopes. In addition, relatively modest monetary support also restricts industrial isotope development.

Representative HOLIFIELD. Would you explain what statutory provisions you are referring to?

Mr. AUCHINCLOSS. Mostly in connection with licensing procedures.

Representative HOLIFIELD. In other words, the industry that wants to use these radioactive isotopes has trouble getting licenses from AEC?

Mr. AUCHINCLOSS. It is a complex procedure, and in some cases the regulations are not easily and quickly applied. We would like assistance in these cases in speeding it up and in knowing in advance exactly what type of regulations must be complied with in order to make a particular installation. I have a few examples of this a little further on.

Representative HOLIFIELD. Very well.

Mr. AUCHINCLOSS. Recently I had occasion to review the budget of the AEC for 1959, 1960, and 1961. While I was pleased to note that the isotope development program is to receive additional funds, I was struck by the fact that, even with these funds included, isotope development is the smallest major item on the budget and that funds allocated for 1960 total only 0.162 percent of the total operating budget.

This, gentlemen, is the item which has been aptly termed "the breadwinner" of the atomic energy program.

As you may know, Tracerlab developed the first commercial beta ray thickness gage; therefore, we have firsthand knowledge of the difficulties associated with turning a technically feasible idea into hardware suitable for industrial application, and I believe that a review of the history of this product is typical of most development projects.

The basic scientific principle on which the beta ray thickness gage operates was demonstrated in 1917, and the first patent application on such a device was filed as early as 1927. It was not until 1948, however, that an industrywide need for such a device, the availability from the AEC of suitable radioisotopes and advanced electronic components previously developed by the Manhattan project, combined to make the development of an industrial beta ray thickness gage an attractive undertaking.

Tracerlab invested large sums of money before a truly satisfactory beta gage was installed and operated successfully in an industrial plant. Each year since, we have continued to invest considerable sums of money in order to improve the equipment and solve other associated problems in broadening its field of application.

Now, the salient point is this: The development of isotope application has historically been performed by small companies, such as Tracerlab, operating with very limited financial resources.

It is obvious, therefore, that if we must wait until the profits from one proven application can pay for the development of a second, that the pace of isotope utilization will be painstakingly slow.

For this reason we have welcomed and applauded the isotopes development program of the AEC. Under this program, funds are made available for investigation of theoretically feasible isotope applications through what is known as the "proof of principle" stage, a point usually reached when a working prototype or laboratory demonstration can be made to prove practical feasibility of the principle.

As can be seen from the previously cited example of the beta gage, substantial funds are still required to perfect an application for the stringent demands of industry.

Allow me to cite an example of an application which is at the present time in the stage midway between the laboratory and industrial usage.

For a number of years now scientists have been aware of the fact that certain chemicals have the ability to trap gases within their crystalline structure, and to retain them there by physical rather than by chemical forces. These compounds in effect serve as a "cage" for the gas and are known to the chemist as clathrates.

It occurred to one of our researchers that this phenomena could be employed to make better use of the radioisotope krypton 85, a radioisotope with a challenging combination of desirable and undesirable physical and radiation characteristics.

On the plus side, it has very useful radiation properties. It is also an inert gas, and since it is incapable of being absorbed by the body, it is relatively safe to use. On the minus side, its gaseous nature makes it difficult to handle and its inertness makes impossible chemical combination with other elements.

It seemed obvious that if the krypton could be "caged" in the aforementioned clathrate, we would enjoy all of its advantages but none of the disadvantages. Under the AEC isotopes development program, it was determined that the gas could be caged with significant leakage by an improved and more efficient method, and as a result, caged krypton 85 became available for use as a solid radiation source.

This program led directly into an even more significant development, a method for measuring the concentration of nonradioactive gases such as sulfur dioxide by means of a Geiger counter. Fantastic though it may sound, the principle is simple and easily understood.

Air containing sulfur dioxide is drawn through a tube packed with granules of "caged" krypton. The sulfur dioxide reacts with the granules and releases an amount of krypton 85 gas proportional in quantity to the concentration of the sulfur dioxide.

The air and krypton is drawn into a chamber where a Geiger counter measures the amount of radioactivity released and thus, indirectly, of course, the concentration of the sulfur dioxide. The sensitivity of the method far surpasses that of conventional techniques, and in our laboratory we have successfully measured sulfur dioxide in concentrations as low as 1 part in 10 billion.

Those of you from large metropolitan areas know that sulfur dioxide is one of the main constituents of polluted air and that its presence contributes substantially to the formation of smog. Those of you with industrial experience know the importance of being able to accurately analyze gaseous mixtures.

This device, a laboratory model which has been successfully demonstrated, is now being developed for general use. Incidentally, gentlemen, I think it is important to note that both the military and civilian branches of the U.S. Government stand to reap substantial benefits from projects such as this.

The Weather Bureau wishes to use a variation of our sulfur dioxide analyzer for ozone analysis of the upper atmosphere. The informa-

tion this provides will make possible a better understanding of the factors affecting weather, and will, it is hoped, substantially improve both long-range and short-range weather forecasting.

The NASA is also considering its use for analysis of trace gases at extreme altitudes. It is no secret, however, that its rate of development is dependent upon several factors, one of the most important of which is obtaining less restrictive licensing regulations.

I am sure that you gentlemen realize that applications employing radioisotopes can have psychological implications. It is our experience that present licensing and registration regulations often create unwarranted apprehension.

I am not suggesting that regulations should be loosened, but only that the same criteria of relative danger be applied to isotope applications as are applied to the use of other potentially dangerous products. For example, radium dial watches and clocks are not generally considered as health hazards, although they do make use of one of the most dangerous radioisotopes known. Yet it has not been possible to obtain permission for general licensing of luminous paint containing tritium or krypton even though the health hazard of these isotopes is practically nil when compared to radium.

Representative HOLIFIELD. Why have you been denied that?

Mr. AUCHINCLOSS. I really cannot answer that. We are applying for the license. I think the Atomic Energy Commission is hampered to some degree because of the legislation under which they act which in some ways affects them similar to those regulations which have recently caused trouble in the food industry, where the fact that the legislation said that there would be no health hazard made them take unusual steps.

In science I believe it is a well-known fact that there is no such thing as nothing. It is always a matter of degree. I think the Commission itself knows the changes it would like to have made. It is just that the regulations have got to be liberalized enough so that we can know in advance what to expect and so that comparable hazards will be accepted.

Radium is accepted. We believe krypton is far safer. We believe krypton will be accepted eventually.

Representative HOLIFIELD. Isn't it true that the field you are talking about, the field of the use of isotopes, and the field of benefits from radiation, are just about the only two fields that small business can get into in the atomic energy field?

The use of isotopes and the use of radiation in plastics and other uses such as the preservation of food, these are about the only areas that the smaller businesses can get into without tremendous capital investments.

Mr. AUCHINCLOSS. That is the business we are in.

Representative HOLIFIELD. Yes; I know.

Mr. AUCHINCLOSS. I do not know what another business might want to do.

Representative HOLIFIELD. My question is directed to the point, I think, of your testimony which is that more encouragement should be given in the field of the use of radioisotopes and more assistance given toward getting the benefits we know to industry.

If there are obstructions, they should be removed because this is a field where a small firm can enter and operate. If it comes to building $50 million reactors and utilizing them, it is a field that requires a tremendous capital investment. But in byproduct uses, this is where there would be a chance to spread the benefits of it, not only wider into industry, but also to give small business a wider chance to get in on this new art.

Mr. AUCHINCLOSS. That is right, sir.

Chairman ANDERSON. Let me ask you one question here. You mention this use of luminous paint containing tritium and krypton. The Atomic Energy Commission, in its report to us yesterday, paragraph 152, said that during the year the Commission substantially increased the quantities of tritium and krypton 85 for civilian use, 1 million curies of tritium and 100,000 curies of krypton.

Do I understand that you cannot get it for your work?

Mr. AUCHINCLOSS. Sir, we can get the material, but we cannot sell it to our customers.

Chairman ANDERSON. Of course, that is a great comfort to you, I am sure. You can put it in the bank, in other words.

Mr. AUCHINCLOSS. Yes.

Mr. ANDERSON. I wonder if there is a representative here from the Atomic Energy Commission. I wonder if I could get some explanation of what is the matter with this. Would you like to step into the lion's den, Dr. Aebersold?

Dr. AEBERSOLD. As you know, sir, there are two roles of the Commission, that concerned with promotional activities and encouragement of use, and that concerned with licensing and regulation.

Chairman ANDERSON. You have a holdback team as well as a go-forward team.

Dr. AEBERSOLD. I would not call the licensing and regulation people a holdback team. Most of these people have been in the atomic energy field a long time and they are interested in seeing the development of peaceful uses. But their responsibility is primarily to see that the uses are very, very safe.

When you say something has to be safe in the atomic energy field, it cannot be half safe. The question is, Should it be 99 percent or 99.9 percent safe, or should it be 100 percent safe? This is the problem.

Chairman ANDERSON. Take his statement as fact for a moment. He said that it has not been possible to obtain permission for general licensing of luminous paint containing tritium or krypton even though the health hazard of these isotopes is practicaly nil compared with radium.

Dr. AEBERSOLD. I agree with that statement.

Chairman ANDERSON. If that is true, do you have any idea why he cannot get the permission to use luminous paint even though the Commission boasts that it has a lot more tritium and a lot more krypton?

Dr. AEBERSOLD. This represents a new policy in licensing for the Commission, to license items that will go to the general public who have no knowledge of radiation protection.

It is true that a person might get a tritium watch or krypton watch, and it would be no health hazard or at least little health hazard. But the question that the Commission faces is how many kinds of products containing activity, like wristwatches, can be licensed? Can you per-

mit every exit sign, every button that you want to push in the dark, can you have all these things, hundreds of products in the public domain, contain radioactivity without the public being in some way aware of this?

CHAIRMAN ANDERSON. Why can't you license the fellow who wants to use it properly even though somebody else may import some watches that have strontium 90 in the dial?

Dr. AEBERSOLD. I agree with you. I think we could materially reduce the radiation from watches and clocks around the country by making luminescent dials with krypton or tritium. Either one would substantially reduce the radiation that the public gets from this source. It is, however, a very small amount of radiation in the first place. I think we could reduce it to almost nothing using krypton or tritium.

Chairman ANDERSON. Doctor, I did not mean to put you on the spot, but if you get a chance back at the Commission, will you try to find out why Tracerlab is having so much trouble?

Dr. AEBERSOLD. Yes, sir.

(Correspondence from the AEC regarding use of tritium or krypton, and a report containing additional information on fission product utilization and availability follow:)

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., March 17, 1960.

Hon. CLINTON P. ANDERSON,
Chairman, Joint Commitee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR SENATOR ANDERSON: During the section 202 hearings, there was testimony regarding the fact that the Commission has not issued a general license for the use of luminous paint containing tritium or krypton.

There are many uses to which tritium (or krypton) paint could be put. Essentially any object might be painted to make it easier to find or read in the dark, e.g., clocks, watches, exit markers, light switches, fuse boxes, keyholes, furniture, doorways, dorknobs, automobile dashboards, telephone dials, etc. In addition, it could be used for novelty effects, including use on children's toys.

Many of these uses would involve consumer products, the production of which would be in the thousands or millions of units. For such uses, it would be impracticable to maintain control once the item left commercial distribution channels. Instead, an outright exemption would be required.

As the number of uses increases, the inventory of radioactive material in general use without control will grow. It is necessary therefore to evaluate beforehand the potential hazard which may arise from two viewpoints. First, the amount of radiation exposure to the general population from the numerous different items must be examined with respect to the radioactive material on objects in current use. Second, it is necessary to consider the amount of radioactive material freed to the environment, via incinerators or scrap operations as items are discarded or replaced.

It is because of these considerations that we have been moving cautiously with respect to permitting use of radioactive materials in consumer products and, in particular, with respect to luminous paint.

As you know, we have established a mechanism by which gaging devices can be distributed on a general license basis to people without experience in radiation protection. These gages can be designed so that there is little stray radiation and little chance that the radioactive material will get out of the device. In addition, the general licensee (customer) is under certain restrictions to safeguard against having the radioactive material get into the public domain.

Such gages are susceptible to general licensing not only because of their design features but also because they have a high intrinsic value, are used for specific industrial purposes, are not likely to come into wide-scale use by the public as would a consumer product, and it is feasible to maintain control through restrictions on subsequent disposition.

In similar fashion, luminous markers containing tritium have been specifically licensed for use in aircraft, the only requirement on the user being a restriction on subsequent disposition of the marker.

In addition, there has been no problem in making tritium or krypton available to qualified users who have experience in radiation protection. Approximately 197 licenses for use of krypton 85 and 515 licenses for use of tritium have been issued.

The major problem to be dealt with is the variety of proposed uses where the distribution is extensive and control is not feasible. This last problem, involving exempt uses, has not yet been resolved for the reasons given above.

Sincerely yours,

R. E. HOLLINGSWORTH,
Deputy General Manager.

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., April 15, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States.

DEAR MR. RAMEY: At the February 18 session of the 202 hearings, several questions were asked by the Joint Committee on Atomic Energy that pertained to the utilization and availability of fission product radioisotopes. The attached report was prepared to provide the Joint Committee on Atomic Energy with additional information on fission product utilization and availability.

Sincerely yours,

DWIGHT A. INK,
Assistant General Manager.

Enclosure: "Report on Fission Product Utilization and Availability."

FISSION PRODUCT UTILIZATION AND AVAILABILITY

Fission byproducts are generally considered a major disposal problem of the nuclear-power industry. The quantity of fission products being accumulated from the continued production of fissionable material for weapons and the increasing numbers of nuclear research, test, and power reactor installations, however, also represents megawatts of potentially useful energy.

Prior to World War II, only natural isotopes and a few very costly cyclotron produced isotopes were available in very small (microcurie) quantities for research. After World War II, however, a whole spectrum of reactor irradiated isotopes and fission product radioisotopes became potentially available in large (curie to megacurie) quantities. More than 200 fission products are found in the fission process, but fortunately, a majority of the highly radioactive fission products are short lived. However, a few long-lived fission product radioisotopes, such as cesium 137 and strontium 90, have characteristics which make them both useful radiation sources and long-term waste storage problems. Therefore, the considerable research and development work performed in the areas of reactor fuel reprocessing and waste disposal since World War II has included a modest amount of research and development on the recovery, separation, purification, fabrication and utilization of fission product radioisotope sources. During this period, billions of curies of fission products have accumulated from reactor operations and are currently stored as neutralized waste solutions but only thousands of curies of fission products have been produced and made available for research and development use.

TRENDS IN FISSION PRODUCT UTILIZATION

Until recently all industrial uses of radiation have been in the well-known techniques of radiography, gaging, tracing, and other process control applications. Recent industrial applications are being found in the manufacture of products which include fission product radioisotopes as part of the product, such as static reducers, luminescent materials, heat sources and radioisotopic power generators. Furthermore, large radiation sources are now being used in plastic processing and medical supply sterilization. During the next decade, the utilization of low-cost fission products could grow dramatically in a newly developing era of industrial ionizing radiation applications.

Ionizing radiation

The greatest growth potential for the use of the fission product cesium 137 is in industrial ionizing radiation applications. Hundred klocurie to megacurie cesium 137 gamma radiation sources could potentially be utilized in such varied fields as chemical synthesis, petroleum refining, drug and medical supply sterilization and the preservation of foods. The technology in these varied fields is currently being developed in research and industrial laboratories with the aid of machines and cobalt 60 gamma irradiators. However, this technology is also applicable to cesium 137. The long 30-year half life and 0.662 Mev. gamma radiation characteristics of cesium 137 enhances its utilization in industrial ionizing radiation applications.

Plastics processing studies indicate a very bright future for lower penetration beta radiation. The irradiation of plastic-coated wire and plastic film has resulted in a superior quality product and significant cost reductions. Strontium 90 with its 25-year half life and its 0.6 Mev. beta radiation coupled with a 2.2 Mev. beta radiation from its yttrium 90 daughter is the best high energy beta emitter presently available in large quantities to meet this need. Furthermore, strontium 90 can be made into virtually insoluble compounds, safely contained, and safely utilized to treat plastic films and to cure plastic coatings on all types of material.

Extensive industrial research programs are underway to learn more about the potential use of ionizing radiation. Research programs sponsored by the Office of Isotopes Development, including the research and development performed at the Brookhaven National Laboratory on high level radiation processing and engineering problems are expected to advance the whole timetable of ionizing radiation and fission product utilization.

Isotopic power

Existing and new requirements for small, reliable, electrical generators that are capable of unattended long-life operation in environments such as in arctic regions, at sea or undersea locations, or in the voids of outer space, have led to consideration of radioisotope fueled power devices. The SNAP III demonstration of a thermoelectric generator represents one line of development in isotopic power devices. Others include thermionic, photoelectric, turboelectric, and fuel cell principles to convert the radioisotope radiation or heat energy to electrical energy.

Conceptual designs and prototype isotopic power generator devices utilizing strontium 90 are being created under a Commission contract with the Martin Co. These generators are being designed to operate unattended on land, at sea or undersea for as long as 10 years. This work has stimulated considerable interest pertaining to Weather Bureau, Coast Guard, Navy, Air Force, and commercial uses of isotopic power units. Isotopic power generators are also being developed which utilize other fission products such as cerium 144, promethium 147, and Krypton 85.

Isotopic power generators, with today's technology, can be used safely to provide reliable power for remote unattended operations, particularly those encompassing missions of long duration on land and under the sea. Furthermore, large-scale utilization and production of fission products can result in isotopic power costs for supplying small quantities of power (less than 1 kilowatt) that are more favorable logistically than existing costs of supplying such power to remote regions.

TRENDS IN FISSION PRODUCT AVAILABILITY

The fission products contained in the reactor fuel reprocessing effluents and the billions of curies of fission products stored in underground waste storage tanks are not available in a useful form. They are, however, potentially available for beneficial use.

An overriding consideration associated with utilizing waste or mixed fission products as sources of radiation is safety. It is important that a radioisotope or radiation source be contained in a manner to minimize ingestion or inhalation hazards. Thus, it is desirable to have the radioisotopic source compacted in a chemical form that is either insoluble or is contained in an insoluble capsule. Its chemical composition must also be stable at elevated temperatures. These conditions should also be met by the compounds formed by the daughter products of the decay scheme to insure continued safe utilization. Furthermore, the

choice of a particular radiation source is determined by (1) power density, (2) cost, (3) availability, (4) half life, (5) shielding requirement, (6) radiation characteristics, and (7) safety and biological hazard considerations with regard to the specific application in mind. Applying these criteria narrows the field of useful radioisotopes and types of radiation sources rapidly. The chemical composition and radiation characteristics of waste or mixed fission products are unpredictable and difficult to control. For many applications, these radiation sources generally do not have sufficient power density or desired radiation characteristics. In addition, the rapid initial decay of short-lived mixed fission product sources results in a high replacement rate and therefore they are not as economical as using a specific radioisotope. Thus, the use of pure fission product radioisotope is clearly indicated and here the choice is limited by availability, cost, and the desired radiation source characteristics defined by the application in mind.

Current fission product availability

The need to develop economical fission product recovery processes and safe radiation sources has stimulated research and development at various national laboratories and production sites for many years. As early as 1948 scientists and engineers advocated the construction of a pilot plant to develop fission product separation and purification processes. A fission product pilot plant was built and it was placed in operation at the Oak Ridge National Laboratory on August 7, 1958.

The fission products pilot plant (F3P) is operated primarily for developing fission product recovery, separation and purification technology, and to gain experience applicable to a future fission product production facility. However, this facility is also capable of supplying 500,000 curies of cesium 137, 250,000 curies of strontium 90, 500,000 curies of promethium 147, and up to 4 million curies of cerium 144 annually for research and development pertaining to the utilization of these fission product radioisotopes. Although the F3P facility might be expanded, such measures would involve spending considerable sums of money and transporting large quantities of waste to supply feed to the F3P facility.

The level of research and development on fission product recovery has been increased at the Oak Ridge National Laboratory and at Hanford, but large-scale availability of fission products is still several years in the future. Current availability of fission products is limited by the capability of the fission product pilot plant and the total output from 1 year of F3P operation will only supply enough strontium 90 for one prototype 100 electrical watt isotopic power device.

Obstacles limiting fission product availability

The state of technology pertaining to the utilization or the recovery and fabrication of fission product sources is not the primary factor limiting the availability of large quantities of fission products. The primary obstacles limiting the production and availability of large quantities of purified fission product radioisotopes appear to evolve from the fact that—

1. Potential users are reluctant to forecast requirements or make commitments for fission products without more specific information on product availability, cost, and possible delivery schedules.
2. Potential producers, on the other hand, will not invest $10 million to $12 million in facilities or make commitments on products, product prices, or availability without some assurance that current and long-range markets exist for large quantities of fission products.

These obstacles become complicated when consideration is given to the fact that—

1. A 3-year leadtime is necessary to provide a production facility to recover and purify fission products on a large scale.
2. The price of a specific fission product is related to the overall market for all of the major fission product radioisotopes; and
3. The overall market for all major fission product radioisotopes is dependent to a large extent upon Government utilization; i.e., Weather Bureau, Coast Guard, naval, and Air Force requirements.

The Commission could, of course, provide a large-scale fission product recovery facility at Hanford, but private firms have already offered to provide such a facility when there is reasonable assurance that markets exist or will exist for large quantities of fission products.

PLANS REGARDING INCREASED FISSION PRODUCT AVAILABILITY AND UTILIZATION

A well-balanced program for the peaceful application of nuclear energy must include the development of the important fields of isotopic power and ionizing radiation.

The Atomic Energy Commission is supporting research and development programs designed to foster and accelerate development of isotopes and radiation. A great deal of intensive research using advanced equipment will be necessary before ionizing radiation is fully understood and new processes are developed that incorporate radiation. However, the AEC-sponsored effort will only point the way for growing research by private industry. Improvements in fission product separation technology and source technology are expected to result in lower costs. This should enhance the use of massive megawatt radiation facilities and isotopic products. Furthermore, the Atomic Energy Commission will provide radiation sources and isotopic power sources to other Federal agencies for prototype development and feasibility studies. It is anticipated that the use of fission products in specific prototype applications will stimulate development of new applications using large quantities of fission products. In addition, the Atomic Energy Commission will continue to cooperate with private firms having an interest in the production and distribution of fission product sources. The Atomic Energy Commission is also continuing process development programs looking toward the possible future conversion of an existing bismuth phosphate plant to a fission product recovery facility.

Chairman ANDERSON. Go ahead. We are interested in it because of the very thing Mr. Holifield mentions. This is a field where small business ought to have a chance to do pretty well. I think the attitude of the Commission is generally to help small business do well. If we can help, we want to do it.

Mr. AUCHINCLOSS. The statement that you made that the Commission is trying to help us is pretty well evidenced by the representative of the Commission here who testified.

Chairman ANDERSON. We have had Dr. Aebersold many times and he does try to help, I know.

Mr. AUCHINCLOSS. The list of potential applications of radioisotopes is too long to discuss at this time. I only wish that members of the subcommittee could join our scientists and research workers on the occasion when new projects are discussed and experience what we call the frustration of knowledge, caused by the seemingly limitless applications of radioisotopes not being developed.

Therefore, I would like to suggest that your Subcommittee on Research and Development consider holding special hearings devoted solely to an evaluation of the industrial potentials of radiation and radioisotopes. Should such hearings be held, I should like to suggest that in addition to such an evaluation, discussions should also include: (1) A reappraisal of present isotope licensing regulations and a study of changes which would encourage wider industrial and governmental usage of radioisotope applications; (2) consideration of changes in the present patent provisions of the Atomic Energy Act which would encourage greater industry participation in an expanded program of isotope development.

Having previously commented on the first of these suggestions, I would like to explain our feelings on the present clauses.

Chairman ANDERSON. Let me say that Congressman Price is chairman of the subcommittee and we will be very happy to call your suggestion to his attention and see if he feels that a hearing is required.

Mr AUCHINCLOSS. Thank you very much, sir.

The Atomic Energy Act describes several alternate patent relationships which can exist between the Commission and its contractors, and leaves to the discretion of the Commission counsel the negotiation of such agreements to the best interests of the Government and the people of the United States. As a result, Government contract negotiators operate under a moral obligation to obtain the broadest and most favorable terms for the Government, and in virtually every instance, require that the contractor abrogate all major rights to preceding, as well as future, discoveries. Therefore, many companies are reluctant to participate in a program where their most creative efforts are made available to their competitors. It is our belief that the AEC development contract should be awarded on terms similar to those granted by the Department of Defense, wherein the Government or any Government contractor has free rights to use any such patents, but that rights for commercial exploitation remain with the organization which invented and developed them.

Representative HOLIFIELD. I would like to ask you a question right there. As I understand it, in the patent provisions of the act, the Atomic Energy Commission has the right to confiscate, you might say, any patents which are of paramount importance to the art. Also those patents which might be of a security nature and which might pertain to the production, or formation, or utilization of weapons. It is not my understanding that in the field of isotopes that the people are interfered with there. If you get isotopic material and you find some use for that material, you certainly are on your own. I don't mean on a Government contract. I mean if you take this krypton material and you go into an experimental field with it, and you develop some particular hardware to use this for a particular commercial purpose, there is nothing to prevent you from getting a patent on that, is there?

Mr. AUCHINCLOSS. The AEC could prevent us under the present rules; yes, sir. They have the right to. Maybe they will and maybe they will not, but they have the right to.

Representative HOLIFIELD. Isn't it a matter of actual record that the increase in private patents in the past few years has gone up from, as I remember, 200 about 3 years ago, something like 400 2 years ago, and something like 600 or 700 this last year? So the obtaining of private patents in these minor fields has gone up very, very fast. I saw a chart on that. Am I not right, Mr. Ramey?

Mr. RAMEY. Yes. In instrumentation and the use of isotopes.

Representative HOLIFIELD. In this very field.

Mr. AUCHINCLOSS. Yes, sir.

Representative HOLIFIELD. All kinds of Geiger counters and dosimeters and all that field where isotopic material may be used. I am wondering if you are not harping on something here which is a traditional complaint, but which does not have too much substance in your particular field. Do you have patents in your work? Does Tracerlab have patents?

Mr. AUCHINCLOSS. Yes, sir.

Representative HOLIFIELD. Have they been interfered with by the AEC in obtaining these patents?

Mr. AUCHINCLOSS. Mr. Holifield, there is the Sword of Damocles hanging over our head. It takes a long time for us to determine

whether we are free and clear or not. We do not have the same trouble with the Department of Defense.

Representative HOLIFIELD. I understand.

Mr. AUCHINCLOSS. We are hoping and praying that somewhat the same policy could apply in the Atomic Energy Commission outside of those matters which are security.

Representative HOLIFIELD. There are one or two areas where the Atomic Energy Commission has a function that pertains to the secret area of weapons where they have to know about these. Under the law there is no doubt that an application for a patent does go to their board. If they claim the patent first, they have to compensate for it if it has commercial value and if you have produced it by your own efforts and by your own expenditure of money. There is a patent board set up to compensate. In the first place they cannot take it unless it is of primary importance to the art, or in the security field. So it seems to me you have a wide field whereby with your own efforts you can obtain patents. I would be surprised if this was not true. It would seem to me that the complaint you are making is a kind of traditional sort of complaint that everyone makes, but on which I have been unable to find a great deal of supporting substance. I have questioned every year these people that come before us with this complaint. Just where does this cripple you. Where does it stop you from getting a patent? I have not found much evidence to support these complaints.

Mr. AUCHINCLOSS. I think there are two sides of it. One is the question of cost. The patents won't be granted unless they are applied for. They won't be applied for unless there is a reasonable chance they will be secured. The developmental work necessary to get a patent may not be done unless we feel we have a chance of capitalizing on that development work.

Representative HOLIFIELD. This is another general statement that is not borne out by the record. The record shows that there has been an increasing number of patents over the past 3 or 4 years applied for and granted to private industry. There has been a decrease in the amount that the Atomic Energy Commission has been applying for. The chart runs downhill for the Atomic Energy Commission and it runs uphill for private industry. I don't know whether you are aware of these statistics that I am calling your attention to or not, but they are available. They are unclassified. They are in our print.

Mr. AUCHINCLOSS. I think there would be more development work done if the policy was the same for the Department of Defense and the AEC. I wonder why it is not practical to have this?

Representative HOLIFIELD. You have a copy of this, don't you?

Mr. AUCHINCLOSS. Yes.

Mr. RAMEY. You are talking there in relation to Government contracts.

Mr. AUCHINCLOSS. Yes; that is right.

Mr. RAMEY. That is a little different than private development. Government money is involved in there.

Representative HOLIFIELD. If you are on that field I would be glad to talk to you about that. I will just say this much: if the Government furnishes the money, you are not asking to do a research job. If they furnish you $50,000 to do a research in a field and pay you a

percentage of profit, you are not expecting in addition to that to have a windfall from all the procedures you discover and be allowed to patent them.

Mr. AUCHINCLOSS. No, sir.

Representative HOLIFIELD. It is a deep subject and I will get out of it in view of the clock.

Chairman ANDERSON. I call your attention to paragraph 190 of the Commission's testimony where they are recommending a loosening of these private background patents. I think it may be of some encouragement to you.

Mr. AUCHINCLOSS. Thank you, sir. I am almost through here.

In substance, it is our belief that the AEC could encourage the isotope development program, and in the broadest sense, further the interests of the people, by establishing the policy that the most favorable patent clause available under the existing Atomic Energy Act should apply to contracts in this field. We believe that this step would relieve the Commission's patent group from the implicit obligation to negotiate for those patent provisions which appeared to be the most favorable for the Commission but which could, by the same token, be most discouraging to potential contributors.

In closing, therefore, allow me to briefly summarize the recommendations which I have made before you today:

1. Greater encouragement, both moral and monetary should be given to the AEC program of developing industrial isotope applications.

2. Special hearing by the Subcommittee on Research and Development to evaluate our present program of industrial isotope application.

3. More realistic isotope licensing regulations should be considered.

4. Patent policies should be reviewed and modified so as to encourage more companies to participate in the isotope development program.

Thank you for your kind attention. If there are any questions I will be happy to explain my views at greater length.

Chairman ANDERSON. Are there any additional questions?

Representative HOSMER. Were you down here last year with somebody else from your company?

Mr. AUCHINCLOSS. I was here last year.

Representative HOSMER. Didn't we get into a conversation about how much money you spend in the promotion of your products?

Mr. AUCHINCLOSS. You mean the advertising program?

Representative HOSMER. At the hearing last year.

Mr. AUCHINCLOSS. I don't remember talking about the advertising program.

Representative HOSMER. One of the things that came up was trying to evaluate just how big the program of sales promotion and so forth in a firm like yours is.

Mr. AUCHINCLOSS. It is very small.

Representative HOSMER. Because in your testimony you complained that industry at large was not adopting the use of isotopes. I was trying to get at whether in addition to the factors you specifically mentioned in your testimony here, the fact that Tracerlab does not have a very big promotion budget, and likewise for some of the other companies engaged in the business might partly be responsible.

Mr. AUCHINCLOSS. We are talking about the definition of promotion. I thought you were referring to advertising. Our advertising budget is quite small. We have a good many field salesmen in proportion to the dollar volume of business in comparison to other types of business. I consider they are a promotionary device. Furthermore, our engineering staff does the same function. It is not in the budget of public relations.

Representative HOSMER. In your own mind, you are satisfied that you make a reasonable effort to sell your product?

Mr. AUCHINCLOSS. We are making every effort we possibly can.

Representative HOSMER. One of the things that your people out in the field are up against in selling these things is a general ignorance of the capabilities and possibilities of isotope applications.

Mr. AUCHINCLOSS. Definitely.

Representative HOSMER. You feel through committee hearings on radioisotopes additional publicity could be given to this whole field, and it would be beneficial to your industry.

Mr. AUCHINCLOSS. I think that would be very helpful, and particularly if we could get a better licensing program so that the people who are about to use isotopes are not deterred because of the complexities of the licensing procedure.

Representative HOSMER. In other words, you may be able to say, "We can make a device to do this, that, and the other thing, but we don't know whether we can get you a license permitting you to use it."

Mr. AUCHINCLOSS. Exactly, or when we can get that license.

Representative HOSMER. Thank you.

Chairman ANDERSON. Thank you very much.

Mr. AUCHINCLOSS. Thank you, Senator.

Chairman ANDERSON. Dr. Frederic de Hoffmann.

STATEMENT OF DR. FREDERIC de HOFFMANN, SENIOR VICE PRESIDENT, GENERAL DYNAMICS CORP.; PRESIDENT, GENERAL ATOMIC DIVISION, GENERAL DYNAMICS CORP.

Dr. DE HOFFMANN. I am senior vice president, General Dynamics Corp., and president of General Atomic Division. Thank you very much for asking me to appear before you. I would like to report to you on some of the nuclear energy activities carried out at General Dynamics Corp.

In your letter of January 20, you listed several suggested topics of testimony, including the AEC's civilian power program and the maritime reactor program. General Dynamics is associated with the Government in major projects in both of these areas and I am, therefore, happy to have this opportunity to discuss them with the committee.

Turning first to the central station civilian power program, I should like to tell you briefly of our progress in development of the high temperature, gas-cooled, nuclear-power plant (HTGR) which is to be built on the system of the Philadelphia Electric Co., with research and development assistance from the AEC up to a ceiling of $14.5 million, plus a waiver of use charges on source and special nuclear material up to a maximum of $2.5 million.

This prototype plant, as you know, is designed for 40,000 kilowatts (electrical) and will be completed in 1963 under a fixed-price $24.5

million contract with Philadelphia Electric and 52 other utility companies of the Nation which comprise High Temperature Reactor Development Associations, Inc., a nonprofit organization. The prime contractor for engineering and construction of the plant is Bechtel Corp. General Dynamics has a contract with AEC covering research and development and, under contract with Bechtel, is to furnish the nuclear steam supply system including the reactor, also on a fixed-price basis.

This prototype, representing the joint efforts of Government and industry, will enable the United States to have the first nuclear power plant capable of steam temperature of 1,000° F. and above and pressure of 1,450 p.s.i or higher, with a net thermal efficiency of about 35 percent. Since the signing of the contracts for the prototype plant last August, the level of confidence in the economic promise of the HTGR has risen steadily, apace with the research and development program.

Representative VAN ZANDT. Have you decided on a date to break ground for this project?

Dr. DE HOFFMANN. I believe that the actual construction will start some time early in 1961, somewhat over a year from now. I might add parenthetically, or rather not parenthetically, but with main emphasis that I am very grateful to all of you as a committee that this project is one of the major projects going forward in this country, and as I mentioned, we are very confident that its economic promise is indeed very high.

Chairman ANDERSON. I think in order to shed light on Mr. Van Zandt's question I should ask—in what State will the ground be broken?

Dr. DE HOFFMANN. Shall I answer for the record, Mr. Chairman? Pennsylvania.

Repesentative VAN ZANDT. I might add that it is not in my Congressional District.

Chairman ANDERSON. No; it is not.

Representative HOSMER. Doctor, your statement here doesn't indicate whether you will clad those elements with metal in the first core or not. I take it in your statement you are thinking about the second core?

Dr. DE HOFFMANN. Actually the situation is such that during the last year we have seen, as we had hoped, enough developmental work coming through on graphite that, while we have not made the final decision which way to go, because it is a little too early, the chances that we might be able to go toward an all-graphite core begin to look increasingly good. We have now seen samples of tubes of graphite of a really large diameter—I am talking of several inches—tubes. We have irradiated some of these tubes, and I must say that these are very, very recent results. They have just come out of the reactor. But in a rather high flux, something like 10 to the 21 nvt., superficial examination of these graphites showed no dimensional changes and no changes in permeability properties.

We are today getting graphites which have permeabilities expressed in the usual units of 10 to the minus 7, which means they are essentially as good or better than we will need for this plant. All this does not mean that we may not still want to fuel the first reactor the other

way, but it looks one heck of a lot better in that direction than it did a year ago.

Representative HOSMER. You would not get 35-percent thermal efficiency?

Dr. DE HOFFMANN. Yes.

Representative HOSMER. On metal clad?

Dr. DE HOFFMANN. Not if we go to metal clad; no.

May I proceed, Mr. Chairman?

Chairman ANDERSON. Surely.

Dr. DE HOFFMANN. Development activity is proceeding at a steadily expanding and accelerating pace at General Atomic Division, where approximately 200 persons are now engaged in various aspects of the work, including experimental developments of the reactor's high-temperature fuel elements and the system's mechanical equipment and fluid systems.

Representative VAN ZANDT. I visited your facility in December, and you mentioned to me at that time you were not receiving information on the United Kingdom's high-temperature reactor development work, and other U.S. gas-cooled reactor development work. Does that defect still exist?

Dr. DE HOFFMANN. The situation I believe is vastly improved. We understand that the final stages of negotiation to conclude a satisfactory agreement with the United Kingdom, respectively, OEEC, Dragon project, so we will be able to get the flow of information and have this solved at an early date.

Representative VAN ZANDT. What about the U.S. gas-cooled reactor development work?

Dr. DE HOFFMANN. Let us look at the U.S. gas-cooled reactor work; I should say it is perhaps important to recognize that we are sort of talking about apples and oranges even though they are both gas cooled, as we discussed last year. Since the HTGR is a homogeneous or let us call it semihomogeneous system, it stands in a class by itself from some of the other work being carried on. Nevertheless, we welcome anything that will pull together all the forces in gas-cooled work in this country, and I think to that I would say the more the merrier. We can never have enough progress in pulling technological information together.

Representative VAN ZANDT. Then I take it the situation is improving.

Dr. DE HOFFMANN. I think that is correct.

Chairman ANDERSON. You would not say it was a case of oranges and apples when you compare Project Turret with your project?

Dr. DE HOFFMANN. I am not sufficiently familiar with that project.

Chairman ANDERSON. A good deal of the information you need is developed by Project Turret at Los Alamos?

Dr. DE HOFFMANN. I don't believe so, because Turret has advanced into temperature regions and situations beyond what the HTGR class of reactors is trying to do. Therefore, right now, if all the work had been completed on Turret, I doubt very much of it would be immediately applicable to the HTGR.

Mr. RAMEY. On the fission trapping, for example.

Dr. DE HOFFMANN. I do not know the details of the fission trapping system of the Turret reactor myself at all. We are doing a great deal of work on the fission product trapping systems.

Mr. RAMEY. Doesn't your staff cooperate rather closely with the Los Alamos Turret people?

Dr. DE HOFFMANN. Yes. We certainly welcome any information we can receive and in return giving any information that we have developed which has become quite substantial over this last year, as you can imagine, with this kind of effort that is on the system.

Mr. RAMEY. I think last year we went through a list of problems you had with your reactor and compared them with the problems that the Turret reactor was going to solve, and they sounded similar.

Dr. DE HOFFMANN. They will sound similar because they are both in that class of reactors. The Turret reactor tries to do something in a different range. As I say, all technology will help each other. I don't think if they had the Turret completely worked out today we would be in a position to build this HTGR plant much quicker, much better, or anything of that kind. I think both statements are true in this case.

Representative HOSMER. I have heard some grumbling about your project being put under Oak Ridge from some administrative standpoint. Would you like to put that on the record?

Dr. DE HOFFMANN. I think it may become clear when we discuss some of this further on here. I think we are dealing with an apple-and-orange situation. I think we are not unhappy at having this under the Oak Ridge Operations Office of the AEC. I think it would be unfair, and the AEC has certainly not done so, if, let us say, of two places developing dissimilar systems, one were to supervies the other in terms of whether he believed the route taken by the other one was the right way to go. I don't think this is actually the case. In other words, there are two separate projects. The EGCR project, which is being carried on at Oak Ridge, and the HTGR which is being carried on by us. I think both have merit and both are a different approach to the system. I think as long as it is administered out of the Oak Ridge Operations Office, which administers both programs, that is fine. If it should ever be that we administered the EGCR or the EGCR people administered us, I expect either of us would have some difficulties in finding objective judgments from both sides. I think there must be a strong distinction drawn between Oak Ridge National Laboratory which has contracted to do one of the approaches, and the Atomic Energy Commission's Oak Ridge Operations Office.

Representative HOSMER. So far you have not felt any cause for complaint?

Dr. DE HOFFMANN. I will mention to you in a moment that I think just because this has not been quite so clearly recognized as being "apples and oranges," we do not agree with some of the statements made in the 10-year program of the Commission. Some of this, I rather suspect, can be traced back to the attempt to put everything in as succinct terms as possible under one heading.

Representative HOSMER. You were real hurt because your project was not in this list that the General Manager put out a few months ago. Is that what you are referring to?

Dr. DE HOFFMANN. No. I am referring to the statement that you just received on the 10-year program. If you will allow me, I will make an explicit statement on that in just a minute.

Representative HOSMER. You feel you were not recognized sufficiently?

Dr. DE HOFFMANN. I don't think it is a matter of recognition. I think it is a matter of the implication that these two things are all one thing. I think it is just technically not so. They both have merit and they should each be worked on their own merit.

Representative HOSMER. You are going to clear that up?

Dr. DE HOFFMANN. Yes.

Chairman ANDERSON. Proceed, please.

Dr. DE HOFFMANN. A facility designed especially for critical experiments on the HTGR core is under construction. Preliminary design work on the reactor pressure vessel is well along, also preliminary design work on the thermal shielding and the core supports structure. A test rig is being constructed to test prototype control rod drives. Irradiation testing of sample fuel bodies continues, along with heat transfer experiments. A large inpile irradiation loop for testing full-diameter elements is under construction. The development of new low permeability graphite, evaluation of the effect of impurities in helium on the mass transport of graphite, development of fission product control—these are among other aspects of the research and development program which are moving forward with encouraging results.

We have not had an opportunity to study in detail the AEC's recently published reports on its Civilian Power Reactor Program Study. However, we have serious reservations concerning the enriched gas-cooled reactor section of part I of this study, since it is, in our opinion, an incomplete status summary of gas-cooled technology. This section leaves the impression that it is in a summary of the heterogeneous (EGCR) gas-cooled reactor and the homogeneous (HTGR) when, in fact, it summarizes data only on the heterogeneous system. We have made known our concern to the Commission's staff that this summary is misleading and does not represent the true status of gas-cooled reactor concepts in the United States.

We are also more optimistic as to the future of gas-cooled reactors than the Commission has indicated in part IV of its Civilian Power Reactor Program Study. The Philadelphia Electric Co. HTGR prototype was undertaken with the strong conviction, and a belief on the part of those in the Government, that it would demonstrate in the first prototype plant those features essential for economic power. If these features are, in fact, demonstrated—and to date we have found no technological reasons why this cannot be accomplished—it should be possible to go ahead immediately to a large commercial version of the HTGR in the 150–300-mw. range. This means to us that HTGR plants competitive with conventional powerplants in many areas of the United States can be built by 1968.

I think it is in those two areas, Mr. Hosmer, that we would disagree with the emphasis placed in the Commission's report, in part I, as we feel there is not a sufficient explanation that the HTGR concept is not talked about. There appears a discussion of EGCR-type technology and a curve which shows an HTGR line. This sort

of thing leaves the impression that both of these are discussed in the paragraphs.

Secondly, there are general statements made as to when these plants can in fact come into use. The statement is by inference drawn that you will have to wait for a whole succession of prototypes and at that somewhere in the 1970's. We do not share this belief.

Representative HOSMER. I am not sure whether you are speaking from what you know now today or whether you are speaking from an entirely opposite standpoint as far as the optimism is concerned. You have not gone far enough with your tests on which to base such a positive statement.

Dr. DE HOFFMANN. I think the basis on which I am making it is that this plant was designed to accomplish something different. It was not designed to go through a series of so many prototype stages. We may turn out to be wrong, but again it should be emphasized that this was the intent of this plan.

Representative HOSMER. In time you will pretty well know.

Dr. DE HOFFMANN. That is right. We know that in 1964 or 1965 we will know whether this is the case. I do not want to exclude their possibility in these time scales.

Among other programs underway at General Atomic Division, covering a wide spectrum of research and development, there are two in particular which I should like to mention here, since they reflect the interest and the investment on the part of private industry in advancing the nuclear art in this country.

One is the research which we are pursuing in the field of controlled thermonuclear reactions, in a joint program with the Texas Atomic Energy Research Foundation, composed of 11 utility companies which operate in Texas. We are making interesting discoveries in this long-range scientific undertaking, which represents the first and largest privately financed program of its kind in the world.

The other program is one which is growing rapidly and which could, in time, bring about truly revolutionary changes in the methods of and economies of power generation. I refer to the field of thermoelectricity—the direct conversion of heat into electricity. I want to include thermionic methods. Results obtained recently lead us to believe that powerplants with overall efficiencies of 25 to 40 percent can ultimately be built and operated, using direct conversion equipment. Operating tests are underway at General Atomic using a number of high-temperature cesium cell and semiconductor direct conversion devices. This field is of special interest to us because high-temperature reactors, such as we are developing for central station power and maritime propulsion, may be able to exploit most fully the potentialities opened up by these high-temperature thermoelectric devices. Associated with General Dynamics in part of the thermoelectric program are eight utility companies of the Rocky Mountain-Pacific Nuclear Research Group, also the San Diego Gas & Electric Co.

Chairman ANDERSON. May I stop you there, Doctor, because I want to get into the question again of the role of the national laboratories. In the chamber of commerce report that I pointed to a minute ago, item 9 in the list of these examples was Los Alamos experimental work on thermionic cells to convert fission energy directly to electricity. The Atomic Energy Commission in its reply deals with the chamber

of commerce item 2–9, and says that this item refers to the plasma thermocouple, a current research project at Los Alamos Scientific Laboratory (LASL).

As far as we are aware, the basic idea originated at LASL, where technology in the exotic materials evolved, and where uranium and zirconium carbide, adequate facilities, and scientific competence are available. This field of research is completely unclassified and is open to industry. LASL has published numerous documents in this area. We encourage laboratories to undertake frontier research of this nature.

The chamber of commerce said it got these items from various companies, and the impression was left that it might have gotten this idea from your organization. Would you care to comment on that?

Dr. DE HOFFMANN. Let me state I was not personally involved. Suppose I state my feeling on the subject, rather than to answer your question directly, which may illuminate how I feel.

Chairman ANDERSON. Do you know whether or not your company did make this comment?

Dr. DE HOFFMANN. I do not. I believe that it is essential that both the national laboratories and industrial companies—in fact, any good nucleus of good research people that can be assembled and really prove itself to be a good nucleus—be allowed to go forward with various research ideas. In other words, I would turn it around this way. I would not suggest that we exclude any one element from doing research in a given field. I think this goes for the national laboratories as well as it does for industry. I think this should be a case where we do not by the direction of funds, for example, end up so that this might in fact come out that way. We ourselves have a very large program in this field now. We certainly welcome any advance in this field that can be made. We would not like to see a policy decision, let us say, which would lead to the fact that the national laboratories are so well suited for this work that if further research and development contracts in this field were to go out, they should only go to the national laboratories.

Chairman ANDERSON. You have put out a very nice booklet on direct conversion and you list the companies participating—California Electric Power, Arizona Electric Power. You don't mention Los Alamos? Actually this work really started at Los Alamos, didn't it?

Dr. DE HOFFMANN. This work was started at Los Alamos and published at Los Alamos. We were at that time looking over the entire field, including semiconductor work. We continue semiconductor work. We think Los Alamos has done a very good job in this thing. We think it is an exciting field. We want to press forward hard. I want to emphasize that the research phase is by no means over and we should as much as anybody else have a large chance at the research program. I don't mean we as General Dynamics. I would hate to see a division arise because in the end it would do the country quite some harm. You would not be able to hold together good groups in various places if you centralized it too much in one or two groups.

Chairman ANDERSON. I want to try to get the philosophy. You went to Los Alamos and picked up Dr. Pidd to head up your work.

Dr. DE HOFFMANN. Let me state how this happened to come about, because it is an interesting one. It so happened that Dr. Pidd actually approached us. I didn't know him. He approached us as well

as six or seven other industrial corporations. And said it was his considered opinion, that the work to prosper really very strongly was now at a stage where you had to combine the basic research and the industrial thing, and he thought there were a few companies in the country—and he thought there ought to be more of this type—that have the ability to combine these two things and really go forward and make these gadgets. This could not be done by simply transferring technology 8 years from now and telling somebody to make it.

Chairman ANDERSON. I don't question that. I only know that Dr. Pidd was working there.

Dr. DE HOFFMANN. May I say this because I think it is important. I told Dr. Pidd that I felt he was engaged in a national laboratory program, and therefore felt that he should probably continue this kind of activity, because this is where he had some of his work and so forth. He informed me that he was not an employee of Los Alamos but a professor at Michigan, was only on temporary loan to Los Alamos as a consultant, and wished to either return to Michigan or go into industry. Under those circumstances would I be willing to take him into the group. I said, "Yes, but generally we will not promise you to work on the thermionic field, only because we want to evaluate what is best."

Once he came he convinced us sufficiently that this was indeed so good that a fair fraction of our effort has gone into it. I think this is a good example of how work should be done between the national labs and industry for the country. I think we both feel that way.

Chairman ANDERSON. Yes. I recognize there is a vast difference in salary. The only point that sort of worries me is that here is a man in common with other people. He was a consultant at Los Alamos, and showed this process to Senator Hickenlooper and various others who came out, and they were impressed, who suddenly transfers to your organization. And then the chamber of commerce comes out and says the national laboratories better get out of the field because somebody else is going to do it. You barely got him under the wire.

Dr. DE HOFFMANN. I can see that the implication is unfortunate.

Chairman ANDERSON. It is the same thing in another case. Dr. Taylor was working with Dr. Ulam on Orion at Los Alamos.

Dr. DE HOFFMANN. Dr. Taylor happens to be in the room and if I could ask for some comments, he could answer. It so happens he did not work on this at Los Alamos.

Chairman ANDERSON. I want to get over this idea that some of us feel that we should not condemn the national laboratories for coming up with a good idea like the thermocouple.

Dr. DE HOFFMANN. By all means, no. We should also not condemn those people that had ideas outside the national laboratories. As you know, I had the pleasure of working for many years in the national laboratory. I am proud of this. I like to carry that tag, rather than the tag that anything I do from there on in stems out of the national laboratories. I think Dr. Taylor developed this idea by himself at the new place of employment where he was. It was a different concept which he felt would make this thing workable and I cannot go into this in open session.

Chairman ANDERSON. I can't either, but I do know the Orion project was talked about, a little at least, in Los Alamos but the military could not afford to put up any money for it. Then it was transferred out to your organization and the military had plenty of money for it.

Dr. DE HOFFMANN. I would be grateful, Senator Anderson, since you mention it—I am unfortunately bound by various open session restrictions not to completely answer—I think it would be one of the best things if it were possible for you to at this stage give many of us, including the national labs, a chance to give you a full report on where this project stands, and what should be done with it. I think this would be one of the finest things that could happen.

Chairman ANDERSON. I think that is fine, because the committee has never been briefed about it. The only thing we know is what we read in the newspapers.

Representative VAN ZANDT. We are looking forward to it.

Chairman ANDERSON. Yes. May I say what I have said to you is not especially reserved for your company? Dr. Chauncey Starr sat next to me at the chamber of commerce dinner, and I had read his speech about the national laboratories. He assures me what he said did not refer to Livermore or Los Alamos, which somewhat reduced my temperature, below 1,400°. I hope we have not reached the point where, now that many of these things have some commercial advantage, you are not going to make any use of these fine ideas from the laboratories unless they can be converted to a commercial experiment.

Dr. DE HOFFMANN. The one thing I would like to add to this is that I think the right way to build up strong atomic energy companies in this field is this. For instance, to us research is not just an adjunct to our business, but really in the foundationstone of the business. I think we have demonstrated that we have a research team that can indeed carry out even the most basic kind of research in the traditions of academic freedom and with the vigor that an industry can supply. So in a sense research is a business to us, just as fuel element is to us. I think there is nothing wrong, and we should not draw this distinction that research should not become a business as of itself. I think we should encourage strong businesses in research.

Representative HOSMER. You feel that you are able to compete with the national laboratories to get the business?

Dr. DE HOFFMANN. Surely. Let me say this, however. I should say I do not agree with what appear to be unwritten policies of the Commission that research contracts as such should go more toward universities, and in fact to a very high degree, than they should to any group that happens to have industrial backing. I understand the reasons, but I am worried twofold. I am worried because the business of large universities is to do good teaching and to have top people to do research, but not to do, in my own mind, mass projectized work because this detracts—this is a purely personal opinion—this detracts in the end perhaps from good teaching and industrial research in the long run.

Representative HOSMER. As a matter of practical necessity the work has to go to universities in order to train these young fellows working for Ph. D.'s.

Dr. DE HOFFMANN. I don't believe so. In other countries there are a number of very fine cooperative arrangements between universities and industry where this is not looked down upon at all.

Representative HOSMER. You are getting a cooperative deal with the University of California.

Dr. DE HOFFMANN. I hope we can. I think these are the right ways to go.

Representative HOSMER. As a matter of fact, it is rather unique. But at the present time we can only get our Ph. D.'s through the universities. You have to give them the work to subsist these boys while they are going through.

Dr. DE HOFFMANN. I agree. I would like to see universities supported. I don't want one segment excluded simply because that segment is thought of by most people as "production." I don't want the word "industry" and "production" to become synonymous. I would like to see good research and development carried on in industry. If it is poor, let us cut it off like anywhere else.

Chairman ANDERSON. The reason I wanted to ask this, I know you spent a long time in my home State, and you think as much of Los Alamos as I do. I wanted to find out your opinion. I feel these national laboratories have made a great contribution and have the potentialities of additional great contributions. I do not say that industry does not also contribute.

Dr. DE HOFFMANN. I fully agree. I think our friendships have kept up in that sense, and we all certainly feel this.

May I proceed?

Chairman ANDERSON. Yes.

Dr. DE HOFFMANN. I come now to the field of nuclear power systems for maritime propulsion and, specifically, to the maritime gas-cooled reactor program (MGCR) which General Dynamics has been carrying out since early 1958 for the AEC and the Maritime Administration.

We firmly believe this to be one of the most important areas of the entire nuclear field, in terms of both need and opportunity. The achievement of an efficient and economic nuclear propulsion system for maritime use is highly important, not only as it involves industry but also from the standpoint of our national interest and prestige.

We are all aware that the ever-increasing costs of labor and fossil fuels provide strong incentives for creating more efficient and more highly automated powerplants. Nowhere is this challenge sharper than in maritime shipping—particularly, the maritime shipping industry of the United States. We have great need, if American ships are to have a substantial share of the world's seaborne commerce, for a propulsion system that is capable not only of matching the economies of oil-fired ships within the briefest possible space of time, but of achieving even lower costs in the long term.

This is the definite goal that has been established for the MGCR which, for the first time, brings together in one compact, efficient plant two advanced, high performance systems—a high temperature, gas-cooled reactor and a closed-cycle gas-turbine powerplant.

The program is directed toward an early land-based prototype, which can be placed under construction during fiscal 1962, to be followed by the first seagoing MGCR vessel.

On the nuclear side of the MGCR system, the gas-cooled reactor is not limited by either engineering or nuclear considerations from achieving high powerplant efficiencies and good economic performance. On the conventional side, great progress has been achieved over the past 15 years in the technical development of high-temperature turbines. Thus, it is now possible to design turbomachinery components which are compatible with the high outlet temperatures and pressures of the gas-cooled reactor.

Marrying these two systems results in a true, direct cycle gas system with only one working fluid and makes available a compact, safe, simple, lightweight propulsion plant. It offers a means of achieving long fuel life, low fuel cost, safety, and other advantages which, together with the high thermodynamic efficiency, combine to give the MGCR strong economic appeal.

Of course, it will be readily appreciated that until the MGCR plant has been built and tested as a prototype one cannot make precise comparison between it and other conventional and nuclear propulsion systems. However, there are some very obvious advantages of the MGCR system which already can be cited:

1. An MGCR tanker would require substantially less machinery space than other systems and, for purposes of comparison, it can be stated that it would use only about two-thirds the space presently taken up by the nuclear propulsion plant on the NS *Savannah*.

2. The weight of the powerplant would be substantially less than that of other systems. It is estimated that the MGCR powerplant will weigh less than two-thirds as much per shaft horsepower and about one-half per unit of cargo as that of the NS *Savannah*.

3. The MGCR thermal efficiency of up to 40 percent is better than that of conventional maritime propulsion systems and also is considerably better than that of any nuclear propulsion system currently under design for mercantile use. This high efficiency extends to part load conditions, as low as 10 percent, which is an advantage not found in steam cycle systems.

4. The MGCR system is especially well suited to exploiting technological advances for incorporation into later plants.

The MGCR program has been underway at General Atomic Division since early 1958, in conjunction with the Corporation's Electric Boat Division whose broad experience in the maritime applications of atomic power date back to the building of our first atomic submarine, the *Nautilus*. Today, at the end of the second year of this program, I am happy to report that its progress has not only lived up to the conceptual expectations, but that design work on the land based prototype has shown this system to be capable of producing even higher efficiencies than were anticipated a year ago.

In recent months, our development program has opened up opportunity to increase the pressure of the helium-gas coolant from 800 p.s.i. to 1,150 p.s.i., and raise the reactor outlet temperature from a maximum of about 1,300° F. to a range of 1,300° to 1,500° F. These are pressure and power levels which are very much closer to those of the ultimate MGCR plant.

These new parameters permit exploration of a wider range of temperature and pressure combinations for seagoing system.

The accomplishments of the MGCR development program during the past year are described in an appendix to my testimony which I have submitted to your committee. I would like to request that this supplementary material be placed in the record.

Chairman ANDERSON. Without objection, that will be done.

(The appendix referred to appears on p. 203.)

Dr. DE HOFFMANN. Perhaps the most significant development of the work during the past year has been a decision to utilize beryllium oxide rather than graphite in the moderator and reflector. As you no doubt recall, this ceramic BeO was the reference core material proposed for use in the very early high-temperature, gas-cooled power reactor, known as the Daniels Pile, back in 1947. During our own evaluation of material for use in the MGCR in 1958, we also recognized the high performance potential of BeO as a moderator material. In both of these instances, however, concern was expressed over the meager amount of information available on the physical characteristics of BeO in the high temperature and radiation environments anticipated. The relatively high cost of beryllium also was prejudicial to its use then.

However, as part of our continuing search at General Atomic Division for a system which would be not only competitive with but more economic than maritime propulsion plants using fossil fuels, we have been continually impressed with the advantages of BeO. Furthermore, data has become available from our own fuel materials experimental program, reflecting favorably on BeO's stability in a high-temperature, high-irradiation environment. Further conversation with BeO manufacturers then led to the conclusion that beryllia could be fabricated in the desired shapes and sizes and, most importantly, that the cost of the finished product would be substantially lower than the cost predicted in 1958.

The beryllium-oxide-moderated MGCR holds promise of achieving higher temperature and higher pressure than those projected for any other nuclear power systems proposed for maritime application. In fact, the high temperatures achievable in the MGCR even when coupled to a steam system instead of a gas turbine plant, permit efficiencies which compare favorably with the most advanced fossil fueled plants proposed for use in the maritime field. However, it is only when this high-temperature reactor is coupled to the high-performance, closed-cycle gas turbine that we achieve the highly desirable efficiencies in the neighborhood of 40 percent.

The economic prospects for the MGCR are made considerably more promising by the adoption of beryllium oxide in the moderator and reflector, due to the high neutron economy of BeO as compared to graphite. This higher neutron economy reflects itself in a fuel cycle cost, using beryllium oxide, which is from 46 to 65 percent of the fuel cycle cost of a graphite moderated MGCR.

In 1967, the overall cost of operating a beryllia-moderated MGCR is expected to be less than the cost of handling that same shipment in a graphite moderated system. Savings in fuel costs will more than offset the higher initial investment in beryllia.

Last year, in testifying before you, and referring to an MGCR plant using graphite, I reported that we could expect the MGCR to compete with conventional propulsion plants with the second gen-

eration of seagoing MGCR's. We now have every confidence that this goal can be achieved with the first seagoing ship, following closely upon the prototype.

Today, on a 20,000 mile tanker run from the Persian Gulf to New York or Philadelphia, using a U.S. built ship and a U.S. crew, it costs from $10.57 to $12.58 to deliver a long ton of cargo, or an average of $11.50 a ton. This is based on a cost of $3 per barrel of oil on the east coast. Based on historic trends in the cost of oil, it is believed that this average cost, using a conventionally fueled ship, will continue to increase.

The first seagoing MGCR tanker, of 60,000 deadweight tons and 30,000 shaft horsepower, coming into service in 1967 or 1968, could be expected to operate at a cost equal to or lower than that for fossil fueled tankers. In comparison with projected 1970 conventional costs, the MGCR could be even more economical to operate.

Representative HOSMER. Is that an overall cost, including capital?

Dr. DE HOFFMANN. This is an overall cost, including fuel. So while you have a more expensive plant, you save on the fuel cycle and thereby get to the same result and hopefully get to a better result at some stage. Of course, you notice this is for large tankers where nuclear power shows its best economic value.

Representative HOSMER. Do you have your fuel cycle worked out to the extent that you could really stand behind that figure?

Dr. DE HOFFMANN. I think you can never stand behind a figure until you have proved it, like eating the pudding. I think our people feel sufficiently competent that unless some rather larger boner has been pulled, which we don't expect, that this is indeed the case, and the prototype will prove these out and hopefully will show us where we may be off and make improvements.

Let us put it this way: There is such a good chance that this is really as we predict that there is every reason to go ahead full speed with making the prototype and with actually testing out these fuel cycles. I think this is the case.

Representative VAN ZANDT. Do you have any information on a similar project in foreign nations?

Dr. DE HOFFMANN. Yes, I do. There is considerable interest around the world in this thing. There is an interest in France in a maritime ship—I would not say exclusively fueled with beryllium oxide, but gas-cooled maritime reactor systems. There is considerable interest by the Japanese who are working on a closed-cycle, gas-turbine system. I did not want to imply that the French are working on a closed-cycle system. I think you will find considerable interest from the Swedes, as a maritime nation who have repeatedly shown interest in this. There was recently a very large symposium in Germany on this subject. We have been approached from Germany on this subject. There has been a very widespread interest.

Representative VAN ZANDT. What about the Norwegians?

Dr. DE HOFFMANN. The Norwegians have not diversified, to the best of my knowledge—I may be giving misinformation here—beyond the one early project they started as a possible boiling water reactor. I think you have to remember here that the resources of the total Norwegian project by the size of the country and the amount they can

develop is not very large. I would not necessarily take them as an indication of like or dislike of systems.

Representative VAN ZANDT. These are all study projects?

Dr. DE HOFFMANN. These are all study projects. This MGCR project that is really proceeding is the one project that leads the world in this kind of work and would really make us come out first as a nation.

Representative VAN ZANDT. Thank you.

Dr. DE HOFFMANN. The MGCR progress report given to the committee in the form of an appendix includes an isometric illustration of the complete MGCR system, a cutaway illustration of the reactor, a flow sheet showing the new performance parameters which I have been discussing, and an isometric illustration of the gas turbine plant. I have here some enlargements of these illustrations which may be of interest to you: (1) Isometric of complete plant; (2) flow sheet; (3) reactor; (4) turbine machinery.

This is relatively a very simple cycle and this is true because it is a once-through gas cycle which takes the coolant not through heat exchangers but directly through a gas turbine which drives the shaft of the ship. The next one, I believe, is an isometric illustration of the gas turbine plant as it appears today.

Chairman ANDERSON. This is similar to the high-temperature gas reactor.

Dr. DE HOFFMANN. No; it is not, Mr. Chairman. It is based on the principle that what we have to achieve here is a very rugged, very compact core, which is one reason we are going toward beryllium. They are exceedingly small cores, and use gas under considerably higher pressure than we would in the HTGR.

Inasmuch as this plant represents the wedding of two very advanced systems, the prudent procedure is to follow the accepted practice normal to the proof testing of such systems—that is to say, to construct a prototype for landbased test operations. In this way, it will be possible to prove out the concept and demonstrate its economic potential before investment in the first MGCR seagoing ship.

Information obtained from these test operations will not only be used to conform the safety and reliability of the separate systems, and the systems in combination—it also will permit the subsequent seagoing plant to be built, with maximum efficiency and economy. With a land-based prototype, the powerplant need not be restricted by the confines of a ship hull, but can be so designed as to permit easy access for experimentation, particularly in regard to the auxiliary equipment.

The basic powerplant of the prototype would, however, follow shipboard installation in sufficient detail to enable duplication of the thermodynamic performance of an operational powerplant, with regard to both steady rate and transient operation.

After the prototype has attained its primary objective of proving the direct-cycle nuclear powerplant concept, it can be of continuing utility as a well-instrumented test facility for future developments, applicable to both seagoing and land-based plants, to obtain still greater efficiencies and still lower operating costs.

As I have indicated, the prototype will be designed to operate at a pressure of 1,150 p.s.i., with a reactor outlet temperature of 1,300° to 1,500° F. Power will be 75,000 thermal kilowatts and maximum

shaft horsepower, 30,000. At the lowest operating temperature contemplated for the prototype, the reactor will achieve a basic cycle efficiency of close to 33 percent.

If this prototype is placed under construction in fiscal 1962, it will be ready for test operation in 1964. Under this schedule, the first seagoing MGCR could be available in 1967 or 1968, with a shaft horsepower in excess of 30,000 and a basic cycle efficiency of 35 percent—a nuclear-powered tanker which, from the moment of its commissioning, would be in economic competition with then current fossil-fueled tankers.

This, then, is a summary of the MGCR program being carried on by General Dynamics, and of the factors underlying our belief that the maritime gas-cooled, closed-cycle, gas turbine system—because of its high performance and extraordinary economic promise—offers to the United States an opportunity to establish a position of dominance in seaborne commerce, at an early date.

Mr. RAMEY. The work you have done so far has been under Commission contract?

Dr. DE HOFFMANN. Yes, indeed, it has been under Commission and Maritime contract, jointly.

Mr. RAMEY. There is not an authorization for the prototype, is there?

Dr. DE HOFFMANN. Is there or is there not, you say? Let me ask Mr. Moore. I want to answer this question very carefully. Mr. Moore, who is project manager of the marine gas-cooled project, can answer this in the most direct and legal fashion.

Mr. MOORE. We have been authorized to design a prototype, but there has been no authorization to construct one. The design authorization is strictly for a conceptual design as opposed to a detailed design authorization.

Mr. RAMEY. How much would a prototype cost as a land based model?

Mr. MOORE. The estimated cost of the prototype is about $25 million.

Mr. RAMEY. Is there any private company that would be interested in building such a prototype?

Mr. MOORE. We have not explored this with any private companies, so I do not know.

Dr. DE HOFFMANN. My answer would be the same. We have considered this a Government program to carry this forward and they have been most enthusiastic about it and continue to be. So we have not explored these routes at all.

Mr. RAMEY. In order to get started on it in 1962, you would almost have to have it authorized in 1961; would you not?

Dr. DE HOFFMANN. I believe, Mr. Ramey, that is a correct conclusion with which Mr. Moore would heartily agree.

Chairman ANDERSON. Will you proceed.

Dr. DE HOFFMANN. In concluding my prepared testimony, I should like to say a word about our national goals in the field of nuclear energy, and what I believe is an essential element to the pursuit of those objectives.

I believe that we, as a nation, must move most directly toward our goal of economic atomic power, and the development and production time for these competitive systems must be held to a minimum, if

those who develop and produce have a close and constant association with the men responsible for the original research and basic concepts. We of General Dynamics have found this to be a fundamental necessary—beginning with the new concept TRIGA research reactors which today are in use or soon will be operating on five of the six continents.

Intensive research must be pursued vigorously within industry itself. There is no prudent alternative, for we have much to learn in many areas fundamental to the achievement of efficient and truly economic systems. Therefore industry must—by its own initiative, and with the cooperation of Government—play a decisive role in the whole broad research and development effort.

Chairman ANDERSON. Are there any additional questions? If not, thank you very much.

Dr. DE HOFFMANN. Thank you, sir.

APPENDIX

TESTIMONY OF DR. FREDERIC DE HOFFMANN, SENIOR VICE PRESIDENT, GENERAL DYNAMICS CORP., AND PRESIDENT, GENERAL ATOMIC DIVISION

THE MARITIME GAS-COOLED REACTOR (MGCR)

Background

The maritime gas-cooled reactor program was initiated on February 17, 1958, as a contract between General Dynamics Corp.. and the U.S. Atomic Energy Commission-Maritime Administration. The program objectives are to develop and construct a prototype of a high-temperature nuclear reactor coupled with a closed-cycle, gas-turbine system for maritime application. The overall project responsibility is assigned to General Atomic Division of General Dynamics and the project is being carried out by a staff of technical personnel assigned from General Atomic and Electric Boat Divisions. Westinghouse Electric Corp. is subcontractor to General Dynamics for the development of turbomachinery for the project.

The MGCR program has been anticipated as early as midyear 1956. Five feasibility studies were completed by AEC contractors by the spring of 1957. Each concluded that considerable development was required on both the reactor and the closed-cycle, gas-turbine cycle. However, when developed, the system will be a high-performance, competitive, compact system.

With this background, the present MGCR program was initiated. The specific objective is to develop, design, build, and test a prototype gas-cooled reactor, closed-cycle, gas-turbine powerplant for a maritime application.

MGCR plant summary

An isometric illustration of the plant is shown in figure 1, and the principal performance parameters of the MGCR prototype plant are shown in figure 2. The beryllium-oxide-moderated reactor heats helium gas to an outlet temperature of 1,300° F., or above. The hot outlet gas then expands through the high-pressure turbine which drives the compressors. It then undergoes further expansion through the low-pressure turbine which drives the propeller through a reduction gear. After leaving the low-pressure turbine, the gas is cooled in a regenerative heat exchanger so that the waste heat subsequently transferred in the precooler and intercooler can be rejected at the lowest possible temperature in order to obtain high thermodynamic efficiency. From the regenerator this gas passes through the precooler and is then partially compressed before passing through the intercooler. Gas leaving the intercooler is further compressed and then regeneratively heated to the reactor inlet temperature.

The basic cycle efficiency of this closed-cycle system is 32.7 percent, which includes allowance for entropy increases in the rotating machinery. The nominal capacity of the MGCR prototype plant is 30,000 hp. at the propeller shaft. Allowing for losses in the reduction gear and 1,000 h.p. for auxiliary ship's load, the required thermal output of the reactor is 75 megawatts.

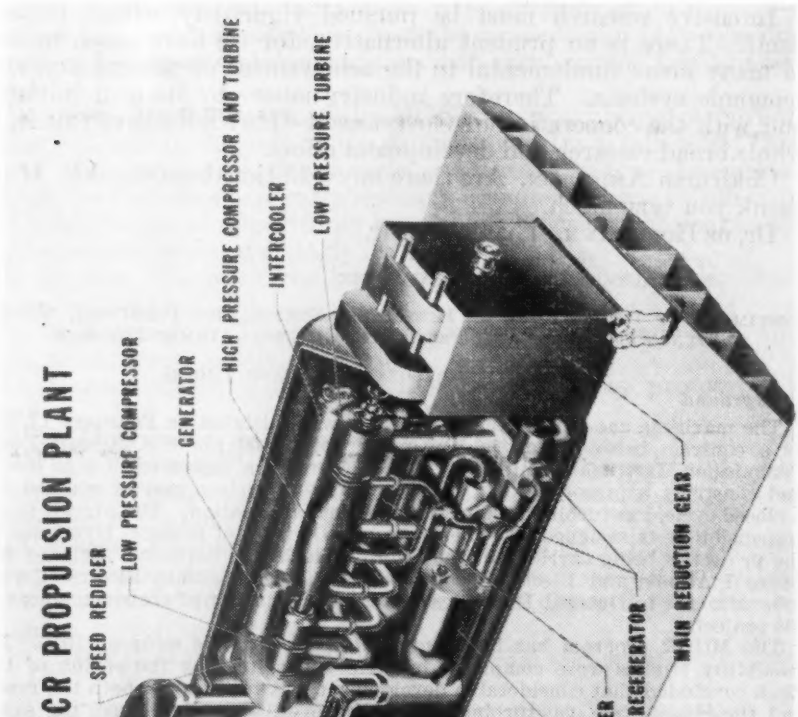

MGCR PROPULSION PLANT
SPEED REDUCER
LOW PRESSURE COMPRESSOR
GENERATOR
HIGH PRESSURE COMPRESSOR AND TURBINE
INTERCOOLER
LOW PRESSURE TURBINE
SECONDARY CONTAINMENT VESSEL
CONTROL ROD DRIVES
PRIMARY SHIELDING
REACTOR PRESSURE VESSEL
COMBINATION BOILER - CONDENSER
PRECOOLER
REGENERATOR
MAIN REDUCTION GEAR

FIGURE 1

Reactor design

An illustration of the MGCR reactor is shown in figure 3. The helium coolant enters the reactor vessel through the outer annulus of the concentric-duct piping at the side of the vessel. The gas then flows down, outside the thermal shield, and enters the core from the bottom. As it passes down from the inlet it cools the thermal shields and maintains them near the temperature of the inlet gas. The flow is orificed at the inlet to the core to maintain essentially constant outlet temperature from each fuel channel. The gas then flows along the surfaces of the fuel assemblies. The hot outlet gas then flows out of the pressure vessel through the inner duct of the concentric-duct piping and thence to the high-pressure turbine.

The beryllium oxide core is 6.4 feet in diameter and is surrounded by an additional 7 inches of beryllium oxide which serves as a reflector. The principal considerations that led to the ultimate selection of beryllium oxide as moderator were the safety features as described later, its efficiency as a neutron moderator, and its stability toward contaminants in the high-temperature reactor coolant. Beryllium oxide has good high-temperature properties, requires no metallic cladding or special cooling for moderator temperature control, and is adaptable to a relatively simple structural design. Further, to avoid corrosion problems and induced radioactivity in the circulating gas, helium was the logical choice as coolant.

Although alternate designs will be evaluated before a final choice is made, the currently proposed MGCR fuel element consists of a cartridge of 19 rods of $\frac{3}{8}$-inch metal tubing filled with UO_2-BeO pellets. Alternate cladding materials are Hastelloy, Inconel, or 316 stainless steel. The rod bundles are encased in a metal sheath and positioned vertically within holes in the core. At MGCR design conditions about 310 such fuel bundles are required.

A design steady power temperature limitation in the range of 1,500° F. up to 1,700° F. maximum surface temperature has been selected for this fuel element based upon the mechanical properties of the cladding materials. With helium as coolant at 1,150 p.s.i., it appears feasible to obtain exit gas temperatures in the range of 1,300°F. to 1,500° F. with this design. Resulting maximum oxide temperatures are lower than those in typical high-power density water-cooled reactors.

Turbomachinery design

The MGCR turbomachinery draws upon technology developed for industrial gas-turbine machinery as well as aircraft jet-engine experience. Designing such machinery for helium requires departures from this experience in mechanical detail. However, the aerodynamic problems of the helium machinery are relatively simple. An illustration of the turbomachinery now under development is shown in figure 4. As compared with conventional equipment, the helium turbomachinery requires more stages, has new materials problems, and has new problems of mechanical construction, seals, and bearings.

In this design the compressor sections are driven by the high-pressure turbine and are mounted on the same shaft. This section of the turbomachine operates at a speed of 12,200 r.p.m. The low-pressure turbine which drives the ship's propeller through a speed reduction gear operates on a separate shaft at the slower speed of 7,600 r.p.m. An alternate arrangement was considered in which the high-speed turbine drove the compressor. However, since this would require a more expensive speed reduction gear, the final choice is believed to offer the best overall performance.

The seals for the unit will consist of helium-buffered and oil-lubricated sleeves. Tilting pad bearings will be utilized in order to eliminate the possibility of oil whip instability.

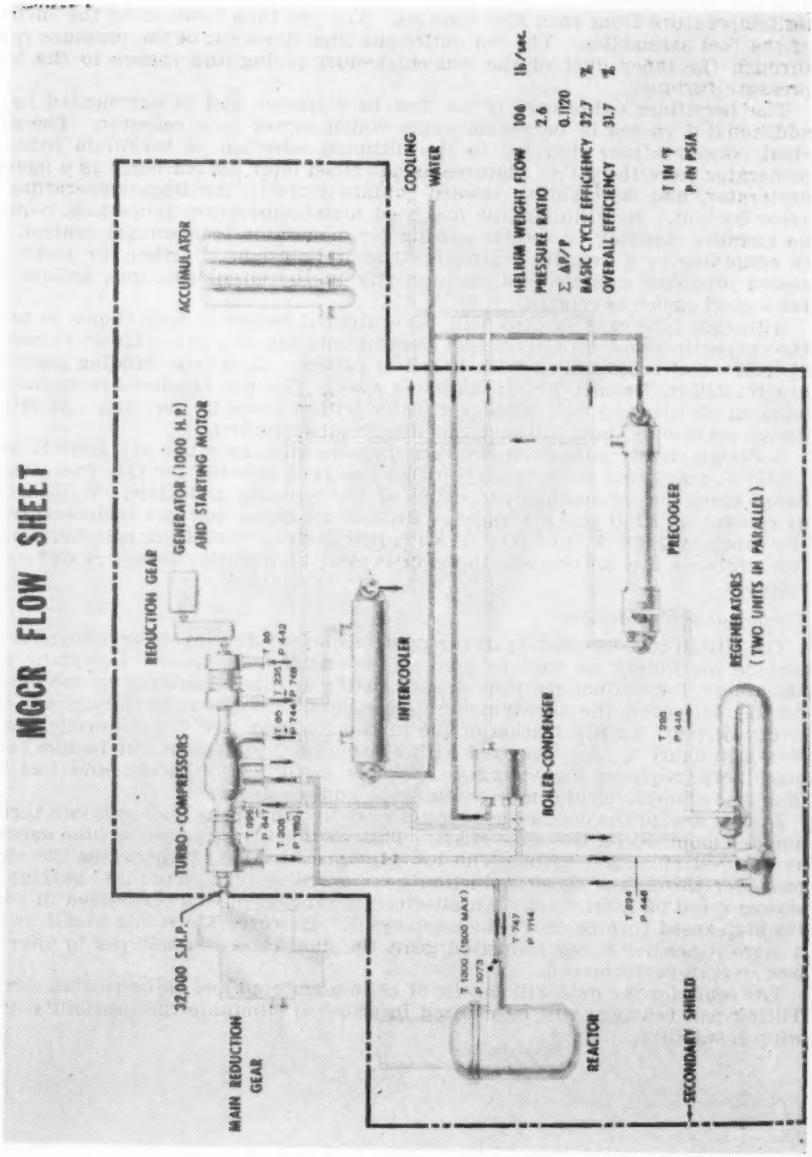
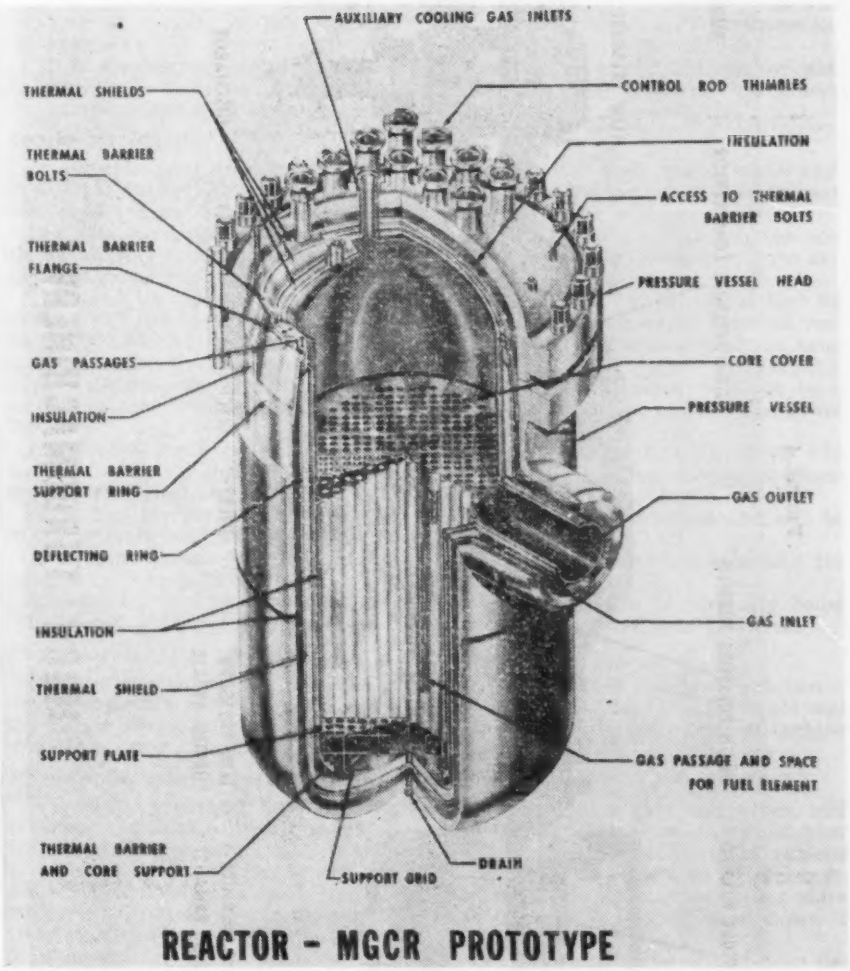

MGCR FLOW SHEET
ACCUMULATOR
COOLING WATER
REDUCTION GEAR
GENERATOR (1000 H.P.) AND STARTING MOTOR
TURBO-COMPRESSORS
INTERCOOLER
BOILER-CONDENSER
PRECOOLER
REGENERATORS (TWO UNITS IN PARALLEL)
32,000 S.H.P.
MAIN REDUCTION GEAR
REACTOR
SECONDARY SHIELD
HELIUM WEIGHT FLOW 104 lb/sec.
PRESSURE RATIO 2.6
Σ ΔP/P 0.1120
BASIC CYCLE EFFICIENCY 32.7 %
OVERALL EFFICIENCY 31.7 %
T IN °F
P IN PSIA

FIGURE 2

FIGURE 3


AUXILIARY COOLING GAS INLETS
THERMAL SHIELDS
CONTROL ROD THIMBLES
THERMAL BARRIER BOLTS
INSULATION
ACCESS TO THERMAL BARRIER BOLTS
THERMAL BARRIER FLANGE
PRESSURE VESSEL HEAD
GAS PASSAGES
CORE COVER
INSULATION
PRESSURE VESSEL
THERMAL BARRIER SUPPORT RING
GAS OUTLET
DEFLECTING RING
INSULATION
GAS INLET
THERMAL SHIELD
SUPPORT PLATE
GAS PASSAGE AND SPACE FOR FUEL ELEMENT
THERMAL BARRIER AND CORE SUPPORT
SUPPORT GRID
DRAIN
REACTOR - MGCR PROTOTYPE

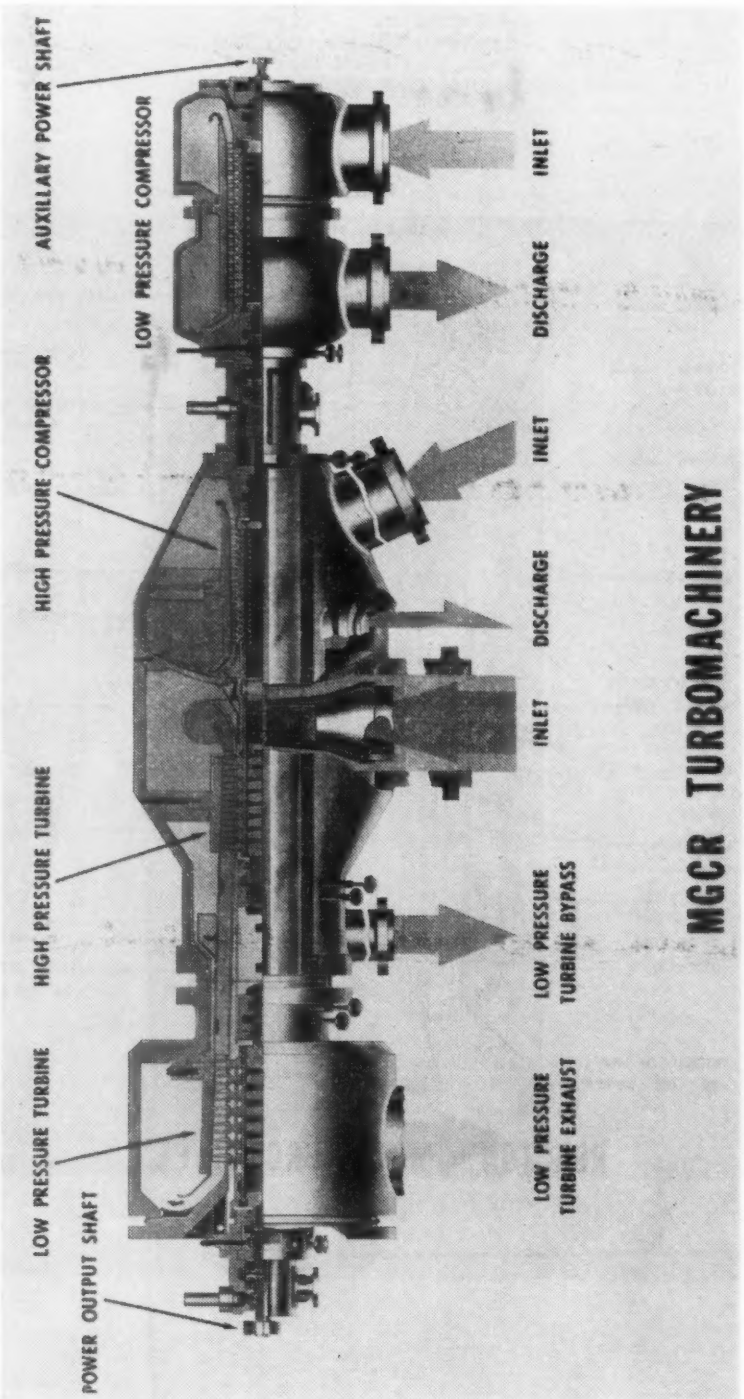

POWER OUTPUT SHAFT
LOW PRESSURE TURBINE
HIGH PRESSURE TURBINE
HIGH PRESSURE COMPRESSOR
LOW PRESSURE COMPRESSOR
AUXILLARY POWER SHAFT
LOW PRESSURE TURBINE EXHAUST
LOW PRESSURE TURBINE BYPASS
INLET
DISCHARGE
INLET
DISCHARGE
INLET
MGCR TURBOMACHINERY

FIGURE 4

Safety features

In selecting the design for the MGCR system, special emphasis was placed upon safety. Some of the principal inherent safety features are:

1. The gas coolant carries relatively little stored energy.
2. Low induced activity is present in the helium.
3. Helium will not react chemically with fuel, moderator, and other reactor and powerplant materials.
4. The beryllium oxide moderator is capable of absorbing, by thermal radiation transfer, nuclear afterheat for a period of approximately 1 hour after shutdown, thereby simplifying the problem of initiating emergency cooling in time to prevent melt down of the fuel elements.
5. The sudden introduction of low-temperature coolant does not result in loss of control of the reactor. (This is a problem with liquid-cooled systems.)
6. Emergency cooling blowers can be mounted above the reactor and cannot be put out of operation by accidental flooding of the machinery compartment such as might occur in the event of a ship collision.

Reactor progress

An experimental program on fuel and moderator materials is well underway. Preliminary irradiation data on UO_2-BeO fuel bodies for the fuel assembly have been obtained and additional irradiation tests are now in progress.

Preliminary experimental data has been obtained which will permit the prediction of fuel element hotspot temperatures and pressure losses in the reactor core due to the presence of the fuel elements.

Tests results reported by others have shown that cold irradiation of BeO up to 3.6×10^{19} nvt. (fast) have produced substantial decreases in thermal conductivity and compressive strength which were recoverable to almost the original values upon subsequent annealing at high temperatures (600°–1,000° C.). From this evidence it appears likely that irradiation damage will not be a serious problem in the MGCR since the BeO temperature will normally be above 700° C.

Irradiation tests on BeO at high temperatures and high fast-flux levels will be initiated in the near future to provide data on the relation between methods of preparing BeO and its irradiation stability up to 10^{22} nvt. (fast).

A critical facility, utilizing BeO, is currently under construction and will be in operation before the end of fiscal year 1960.

A General Atomic BeO laboratory is under construction and is scheduled for completion March 26, 1960.

A control rod drive has been designed and a prototype is currently being constructed. Plans for a control rod drive test facility have been prepared.

Turbomachinery progress (status of development)

Preliminary tests have demonstrated the feasibility of the proposed turbomachinery seals and oil-helium separation system, and a test of a full-scale seal mockup is planned in the near future. Models for aerodynamic tests of turbine and compressor components are currently being constructed.

Progress on other propulsion system components

A model regenerator has been tested with helium at high temperature, and pressure and data collected on which the calculation of pressure drops and heat transfer coefficients for the protoype can be based. Stress analyses of various propulsion system arrangements have demonstrated the feasibility of eliminating expansion joints in the helium piping and mounting the reactor on flex plate supports. Preliminary transient analyses of the MGCR system have shown it to be stable and controllable.

In summary, design solutions to the major problems have either been developed or are obviously developable at reasonable cost. The principal remaining major uncertainties concern the long-term irradiation resistance of BeO at elevated temperatures, the development of economical methods of fabricating moderator shapes, and the proof testing of components. Therefore, a proposal for construction of a prototype appears to be justifiable.

Prototype size and flexibility

Since the MGCR powerplant represents an extension of technology in both reactors and turbomachinery, it is desirable to build an experimental prototype rather than an operational unit. In this way the systems can be designed to permit easy access for experimentation free from interference by operational requirements. This adaptability of the reactor, together with the flexibility of the closed gas-turbine cycle, will permit the prototype plant to be used as a facility for testing future developments in fuel elements aimed at obtaining higher cycle efficiencies and better neutron economy. Hence, a land-based prototype is considered preferable to a shipboard installation for the first MGCR plant.

The 30,000-shaft-horsepower rating for the prototype powerplant is in the range of power levels expected to achieve economically interesting service. It also calls for turbomachinery whose physical dimensions are about as small as feasible for rugged machinery of high efficiency. Lower power levels may be obtained by operation at lower cycle pressures. Future plants of higher power ratings can be easily extrapolated from a plant of this size. Thus, at this power level, the reactor, machinery, plumbing, and other hardware are at the size required to establish reliability before such a plant is installed aboard ship.

Summary of plant data

A summary of the principal design parameters of the MGCR prototype is given below.

Power:	
At propeller shaft	30,000 (max.).
Reactor, MW (thermal)	75.3.
Auxiliaries	1,000 horsepower.
Net shaft efficiency	31.7 percent.
Cycle efficiency	32.7 percent.
Reactor:	
Moderator and reflector	Beryllium oxide.
Core (active lattice):	
Diameter	6.4 feet.
Height	6.4 feet.
Reflector thickness	7 inches.
Fuel	Enriched uranium (5 to 10 percent).
Fuel element	Heterogeneous 19-rod bundle ⅜-inch rods of UO_2 diluted with BeO. Metal clad (materials being evaluated are Hastelloy, Inconel X and No. 316 stainless steel).
Fuel loading	Uniform.
Number of control rods	16.
Core life (at full power)	4 years.
Coolant	Helium.
Coolant pressure	1,150 p.s.i. from high-pressure compressor; 442 p.s.i. into low-pressure compressor.
Reactor inlet temperature	745° F.
Reactor outlet temperature	1,300° F. (1,500° F. max.).
Turbomachinery:	
Turbo-compressor speed	12,200 r.p.m.
Power-turbine speed	7,600 r.p.m.
Axial-flow stages:	
High-pressure turbine	8 stages.
Low-pressure (power) turbine	7–8 inches.
Low-pressure compressor	17 inches.
High-pressure compressor	21 inches.
Overall length	32 feet.

Chairman ANDERSON. Mr. Leggett.

STATEMENT OF W. D. LEGGETT, JR., VICE PRESIDENT, ENGINEERING, ALCO PRODUCTS, INC., SCHENECTADY, N.Y.

Mr. LEGGETT. Mr. Chairman and gentlemen, I am W. D. Leggett, Jr., vice president of engineering, Alco Products, Inc., Schenectady, N.Y.

It was my privilege to appear before your committee in 1957 and again in 1958. I have reread my statements and the oral testimony given on those occasions and feel that I have little to add to the case for the small nuclear-power reactor. As a tool for development and a power generator for remote areas, we still feel that it has a definite place in the program. Costs and delivery times of medium Army reactors have decreased. This progress has been reflected in the one small process heat and the one small industrial power reactor for which bids have recently been taken.

During the 1959 hearings of this committee I was in Europe evaluating possible applications for small powerplants which had been developed by our associates over there. The results were so disappointing that by mutual agreement we dissolved the association. The prospects for the application of small nuclear power plants abroad are so limited as to be of almost no interest for the present.

It appears that Alco's work in the field of nuclear power engineering will continue to be almost entirely on the Army's nuclear program. We are quite pleased, therefore, to see this program as one of the topics on which the committee particularly desires discussion this year. You may recall that Alco Products made a policy decision to stay in a preferred range of 1 to 20 mwe. where we have been building powerplants for over 100 years. In the Army designation we are builders of medium, not small, plants. We are happy to be the major supplier of medium plants to the Army. The association has been productive if not profitable. Unfortunately, the Army has a very limited budget and has also other contractors who are in somewhat the same situation as ourselves.

Alco's other nuclear activity has been the supply of components for nearly all of the nuclear powerplants built or building in this country. Manufacture of equipment actually exceeds in dollar value our work in complete nuclear powerplants. I realize that this committee is primarily concerned with programs rather than hardware, but I am sure you appreciate the fact that the manufacture of the hardware is a business which also entails expensive preparation. The volume of this business is dependent on the total construction of nuclear powerplants and just now is a subject of some concern to industry.

As a supplier of medium powerplants to the Army we have completed the SM–1 (former APPR–1 at Fort Belvoir); the design and nuclear portions for the SM–1A in Fort Greely, Alaska, which are now being installed, and the PM–2A, which is a skid-mounted portable powerplant to be installed in a remote arctic location during this coming summer. Components for this unit are now under test at our Dunkirk, N.Y., plant.

Incidentally, I very much hope we will have a number of the members of the committee up in Dunkirk for a look at the PH–2A next month.

In addition to these plants, we have contracts for the design of the SM–2, a larger and more advanced type of pressurized water plant.

Representative VAN ZANDT. Is your plant located on the New York Central tracks?

Mr. LEGGETT. Yes.

Representative VAN ZANDT. What about Dunkirk?

Mr. LEGGETT. The Dunkirk plant is between Erie and Buffalo and the New York Central does go through Dunkirk.

Representative VAN ZANDT. While traveling on the New York Central Railroad the other day I recall seeing the plant.

Mr. LEGGETT. Yes, sir.

I believe that the committee is aware of the capabilities of the nuclear plants we have built. We are gratified at the success that we have had with them. We completed the first plant ahead of schedule in less than 31 months. The Fort Greely plant was to be completed in 24 months, but was delayed by labor troubles in Alaska. The PM–2A contract called for delivery in 16 months and is scheduled for operation at the site in 20 months. We don't recommend a schedule this short, but we do understand the situation and are making every effort to cooperate with the Army in adapting to the very short building seasons in the Arctic. These times are included to show what can be accomplished in the design and erection of small powerplants compared to the requirements for large ones.

In spite of what appears to be a successful program, there are, so far as we can ascertain, no plants for remote stations in the Department of Defense budgets for 1960 or 1961. Perhaps this should be of more concern to national defense than to an individual manufacturer, but it is certainly more obvious in the manufacturer's forecast than in the Department of Defense budget. Considerable effort has been expended by the Army, AEC, and industry in bringing these powerplants to their current state of development. After building three such plants, Alco is confident that substantial cost reductions and technical improvements can be realized by a continuity of such development. I think it is pertinent at this point to add that the three plants we have built were obtained on fixed price, guaranteed performance, competitive bids. I feel I am speaking for our segment of industry when I say our most pressing need is something to compete for.

It is generally conceded that there are remote locations where the nuclear powerplant provides the best logistic solution. There are geographical areas where the nuclear powerplant even in its present state of development is economically competitive because of the very high cost of delivering fossil fuel. The history of all power developments indicates that a new type of plant must find such a special situation in which to grow and develop and from which it can expand.

The remote location is the best justification for the small shore-based nuclear plant. The issue is confused, however, by the fact that

in this area the military is the only customer, regardless of economics. There is an understandable reluctance on the part of the military forces to include in a facilities budget, which as the Congress is aware has always been limited, an item for a nuclear powerplant entailing a capital expenditure higher than required for conventional type of powerplant. This reluctance is increased by the fact that the high fuel cost for a remote location does not show against a particular job but is prorated over many accounts. I am not criticizing the accounting system. I simply observe that in this particular instance it serves to remove an incentive for the installation of a nuclear powerplant.

In connection with most nuclear ventures both here and abroad, it is customary for governments to provide an incentive of some kind, generally money, to overcome the cost differential between the conventional and the nuclear powerplant. The idea of providing such an incentive to the Department of Defense to go ahead with the development of shore-based nuclear power stations is not new. It has been rejected largely, I think, on the philosophy that if the Department of Defense feels that the development of these powerplants is important they are in a position to budget for them. In the case of the Navy, this has been done, because there is a clear-cut case, particularly in submarines, for the nuclear powerplant. The Army has carried on a limited program in the past, but for the future it does not appear to exploit to the full even those remote locations under the Department of Defense which are economic or close to being economic today.

I tried to make clear, Mr. Chairman, that this is an across-the-board program and not just an Army program.

Mr. RAMEY. As you know, the Commission is making a study of these remote base plants and we are due for a report on them April 1 of this year, which will be in between our authorization hearings, with some idea of considering these plants if authorization did seem to be justified. We also have been apprised of the fact that in the Navy they had considered going in for a plant with the Navy paying the conventional amount for a land-based plant such as at Guam, with the AEC paying the differential; but, as your statement implies here, apparently that whole onus was put on the Navy to put up the capital amount, and therefore they dropped it.

Mr. LEGGETT. That is my understanding. I am delighted to hear that your reporting date is as early as the 1st of April on this. I did not realize it was quite that soon. If there is to be an Antarctic plant particularly, the schedule will have to be pushed along or we lose another building season in the Antarctic.

Chairman ANDERSON. There is a great deal of interest in the Joint Committee in the type of plant that might be available for the Arctic areas, particularly the Antarctic; and also a desire on our part to investigate what might be done in a place like Guam. It did seem too bad that the program there was sort of canceled because of the high initial cost without an examination as to whether that high initial cost might eventually be repaid by a lower operating cost. The matter is not yet settled by a long way.

Mr. LEGGETT. This is one of the accounting system points that I wanted to bring out in my statement this afternoon. There is quite

a difference in the facilities budget and the operating budget of the various services.

Chairman ANDERSON. Yes, indeed. The situation with Guam is that there might be, and undoubtedly would be, a higher initial cost for the installation. There also might be a very substantial saving, because of the very extremely high cost of bringing in fuel. We hope that there might be some balancing of the two along with some credit for the research and development that would go into that sort of plant. We would spend some money on it no matter where it was built.

We were only sorry that time had not seemingly permitted it to be worked out. I do believe that Mr. McCone is sympathetic. He certainly got some encouragement from Mr. Van Zandt and some of the rest of us.

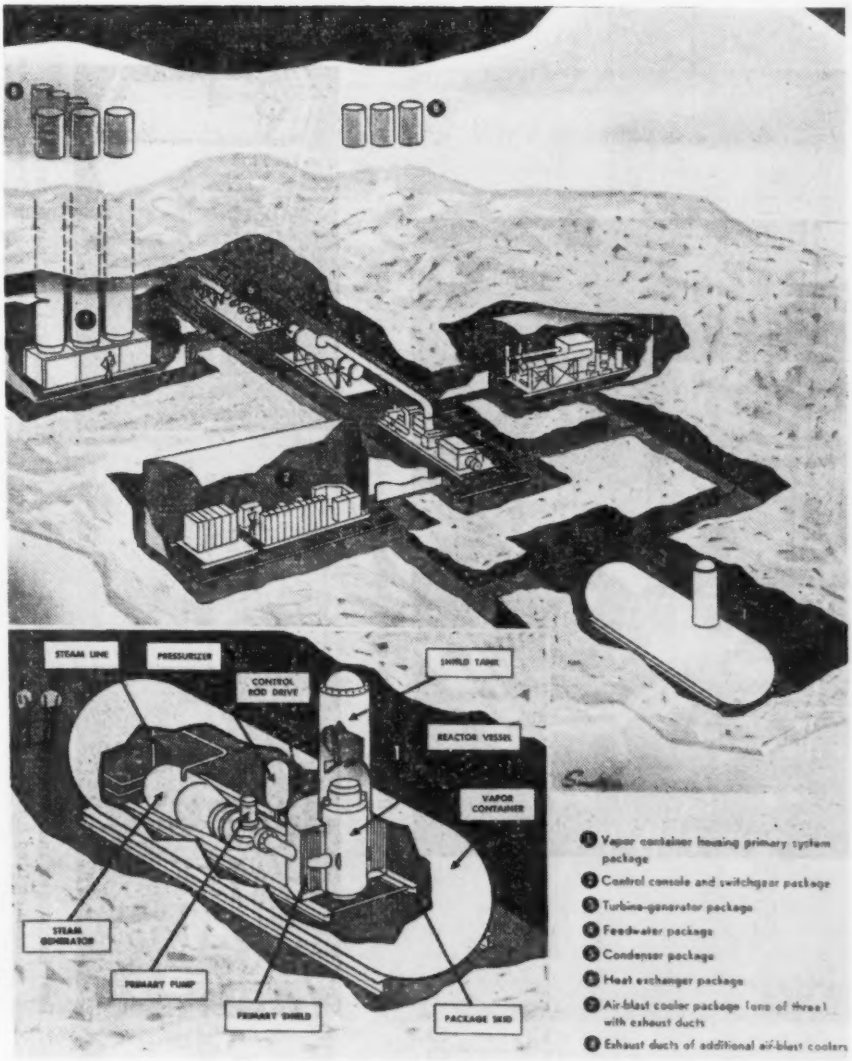
Mr. LEGGETT. The whole tenor of our paper is that we are not going to get there if we don't build some powerplants.

Representative VAN ZANDT. This program impresses me, especially because of my experience in war. I recall in World War II how they dragged these huge generators into the area and then fed them with oil, necessitating a constant line of communications to supply the oil. Under this program one can move in one of these small packaged reactors and you get the needed energy. In time of war costs mean nothing.

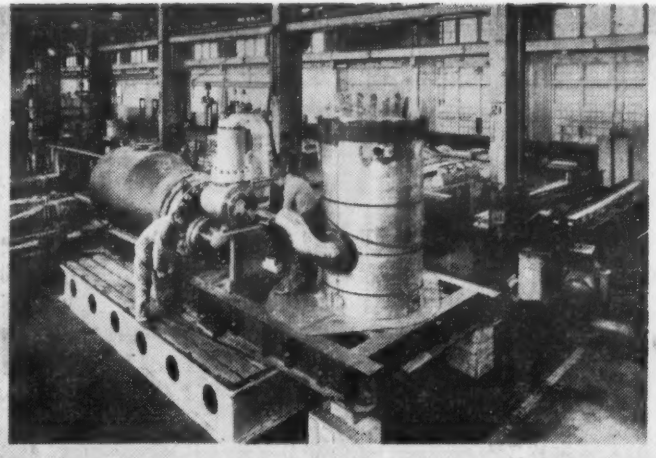
Mr. LEGGETT. Yes. We think this is particularly pertinent in the Arctic. I would now like to show you an artist's conception of the nuclear powerplant which we are now building, installed in a remote Arctic location. This plant, as you can see, is below the snowline in tunnels in the ice. We have found out late in the program that the reactor does have to have vapor containment which shows in this cutaway view even in this remote location. So we are building the vapor containment. Steam from the reactor and steam generator skid goes into the steam turbine and then into the condenser. Part of the steam goes into this heat exchanger to produce heating steam so that you don't contaminate the whole system with return water from the heating system.

The control skid (item 2), the feedwater skid (item 4) and the airblast coolers are located in cross tunnels as shown.

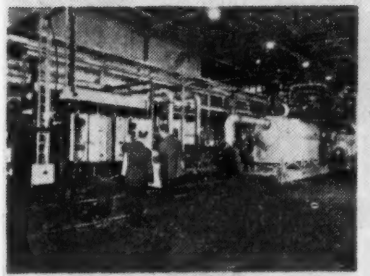
The physical progress on construction and test of PM–2A is illustrated by these pictures. The reactor skid which is shown here during construction is as of today ready to move into the test area at Dunkirk. To keep within weight limits this unit is actually made up as two skids bolted together. The assembled plant—you may have to look at the picture attached to the statement—is a little surprising when you first see what is labeled as portable. It is portable though. It is built on skids, designed so that it will go into an existing aircraft which can be landed on the ice. But it takes up quite a bit of space. It is a little bit shocking to see it the first time. However, it is as good as it was planned to be and it compares very favorably in total overall weight and volume with a 1-year supply of fuel which has to be hauled in the same way for a conventional plant.



Artist's conception of skid-mounted portable nuclear powerplant installed in remote arctic location.

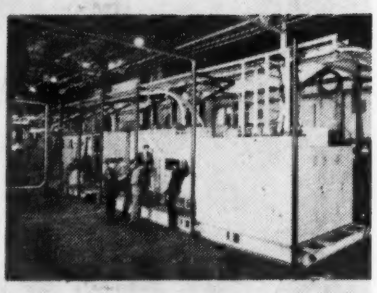


Reactor and Primary Equipment - skid being assembled



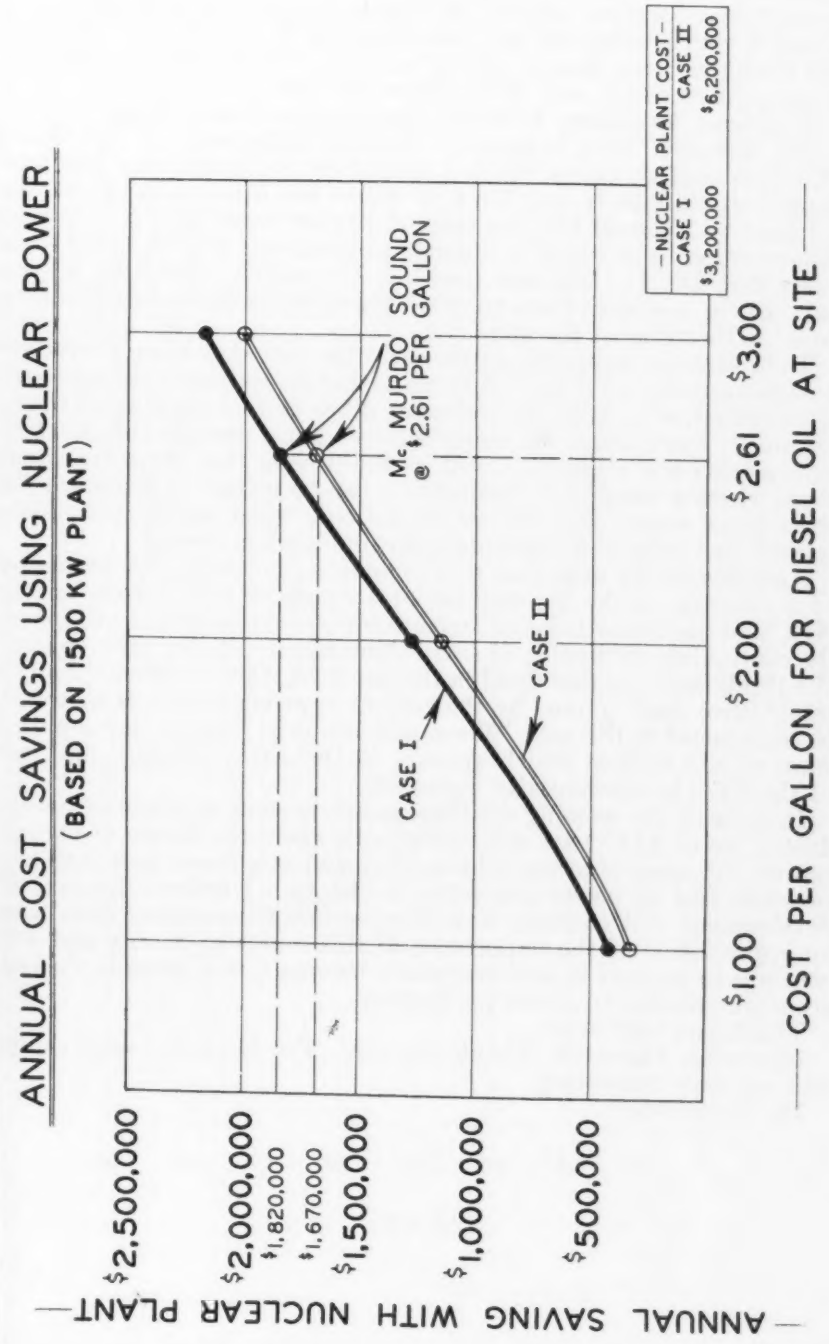
Heat Exchanger and Condenser Skids Assembled for Test

Components for Skid-Mounted Portable Nuclear Power Plant



Control and Switchgear Skids Assembled for Test

ANNUAL COST SAVINGS USING NUCLEAR POWER


ANNUAL COST SAVINGS USING NUCLEAR POWER
(BASED ON 1500 KW PLANT)
—ANNUAL SAVING WITH NUCLEAR PLANT—
$2,500,000
$2,000,000
$1,820,000
$1,670,000
$1,500,000
$1,000,000
$500,000
$1.00
$2.00
$2.61
$3.00
—COST PER GALLON FOR DIESEL OIL AT SITE—
Mc MURDO SOUND @ $2.61 PER GALLON
CASE I
CASE II
—NUCLEAR PLANT COST—
CASE I $3,200,000
CASE II $6,200,000

52950—60——15

Now I show you a curve, Mr. Chairman, which we have made up to show annual savings which can be realized with a nuclear plant. For a particular location, namely, McMurdo Sound, where diesel fuel is listed in your hearings of last year as costing $2.61 a gallon. You can see from the curve there would be a saving of $1,820,000 annually on a powerplant which costs $3.2 million installed.

Chairman ANDERSON. It would take less than 2 years to pay for it.

Mr. LEGGETT. That is correct. This is what shows on this chart. We have another curve which I now show you indicating just how long it would take to pay for it or where you break even again. In all honesty I should tell you these charts are made out on a 20-year amortization basis which is common practice and I think is the same basis that Dr. De Hoffman used for his tanker. Actually, as you can see, in one and three-quarters years you will realize a saving equal to the value of the plant.

I am sure the committee appreciates the fact that these charts are based on estimates. I won't even claim that the estimates are unbiased. Cost of fuel, or installation and many other factors are difficult to determine. Eventually, the using services must provide this kind of information and analysis. Still it would seem that there are situations where a reasonable justification can be made. A program for these areas would lead to cost reductions, wider application, more reliable and fully developed plants available when needed.

Accordingly we urge that this committee encourage the formation of a program in the Department of Defense or jointly between the AEC and the Department of Defense for a program which will insure the continuing production of small shore-based military powerplants. We think that a modest fund in the hands of AEC to offset the effectively "free fuel" offered by the current appropriation system would be constructed to this end. We would also urge that the development fund of $15 million which appears in the Army reactors program of the AEC be substantially increased.

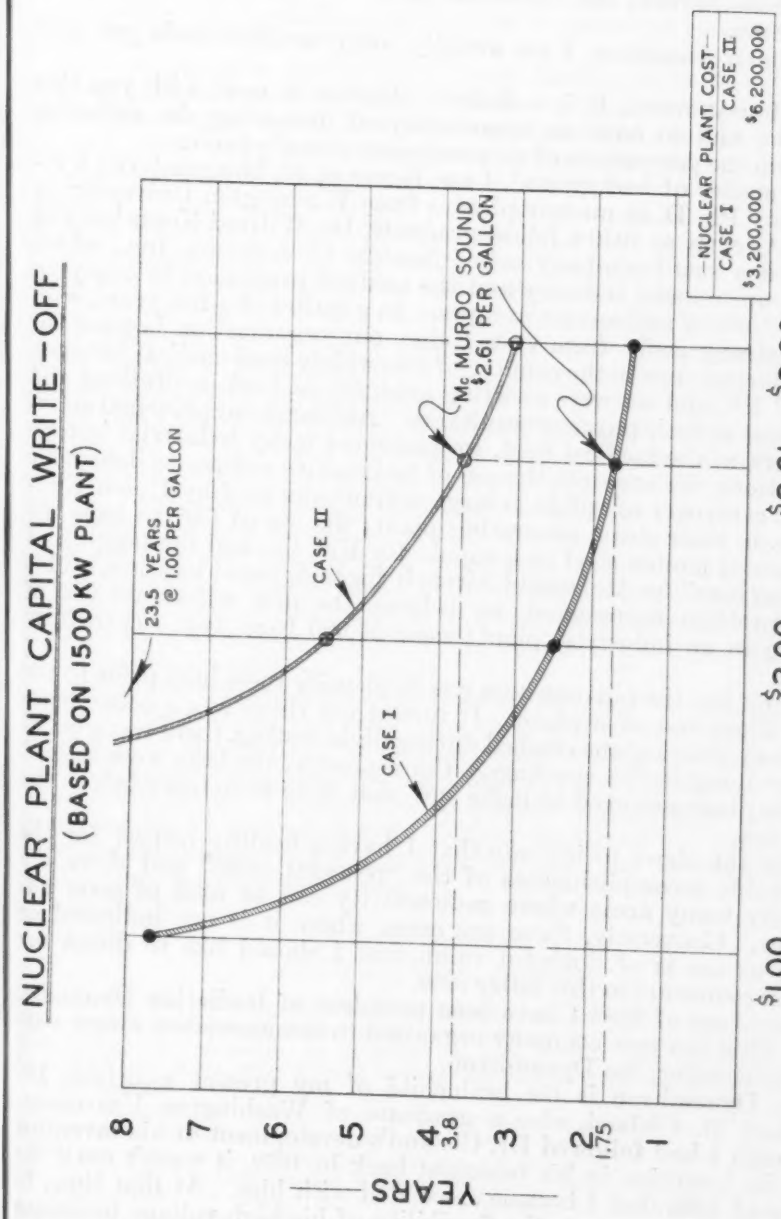
In spite of the seeming disillusionment in some quarters of the industry, we at ALCO are still enthusiastic about the future of nuclear power. It appears to me to have developed at a faster pace than any previous fuel or power generator in history. I believe this rate of development will continue now because our Government does have an appreciation of the importance of this source of energy and will continue to support it, and eventually because it will provide the best economic solution to power production.

Thank you very much.

Chairman ANDERSON. Thank you, sir. You have said some things that are very interesting.

Dr. Morganstern.

NUCLEAR PLANT CAPITAL WRITE-OFF


NUCLEAR PLANT CAPITAL WRITE-OFF
(BASED ON 1500 KW PLANT)
23.5 YEARS @ 1.00 PER GALLON
CASE II
CASE I
Mc MURDO SOUND $2.61 PER GALLON
NUCLEAR PLANT COST
CASE I $3,200,000
CASE II $6,200,000
8
7
6
5
4
3.8
3
2
1.75
1
YEARS
$1.00
$2.00
$2.61
$3.00
FUEL COST PER GALLON

STATEMENT OF KENNARD H. MORGANSTERN, RADIATION DYNAMICS, INC.

Dr. MORGANSTERN. Mr. Chairman, gentlemen, thank you for staying over for me.

Chairman ANDERSON. I am awfully sorry we have made you wait so long.

Dr. MORGANSTERN. It is a distinct pleasure to meet with you this afternoon and to have an opportunity of discussing the radiation field from the perspective of an accelerator manufacturer.

As a matter of background, I am Kennard H. Morganstern; I received my Ph. D. in nuclear physics from Washington University in 1951. As early as 1950 a fellow graduate, Dr. Wilfred Konneker and I started a small company called Nuclear Consultants, Inc., which was set up to assist industry and the medical profession in applying the new tools of radioactive isotopes. In a matter of a few years, with a very strong assist from Oak Ridge, our organization became the second largest user in the country of two widely used medical isotopes, I^{131} and P^{32}, and we were assisting over 200 medical institutions and physicians as their physics consultants. Although our principal activities were in the medical field, we pioneered many industrial isotope applications, for example the use of radioactive sodium to determine droplet carryover of solids in large evaporators used by Union Electric Co. in their steam generating plant; the use of Co^{60} to gage the interface of molten steel in a copula for Key Co. and the tagging of "bucking bars" for McDonald Aircraft for their rapid location. This latter problem represented, we believe, the first wide-scale use of labeling in an industrial plant; some 20,000 bars were successfully tagged.

I might say the purpose here was to identify these bars prior to the actual flight test of a plane. It turned out there was a coincidence that every time a plane crashed during flight testing, there was a bucking bar lying in the wreckage. Consequently, the bars were tagged and the plane surveyed to make sure that none were there before the flight test.

I cite the above to indicate that I have a healthy respect for the remarkable accomplishments of the "peaceful atom" and there are certainly many areas where radioactivity can be used to good advantage. Conversely, there are areas where it is not indicated or where its use is of doubtful value, and I should like to direct my further comments to this latter case.

Since June of 1958 I have been president of Radiation Dynamics, Inc. This is a new company organized to commercialize a new particle accelerator, the Dynamitron.

The Dynamitron is the brainchild of my present associate, Dr. Marshall R. Cleland, also a graduate of Washington University. Although I had followed Dr. Cleland's development of his invention from its inception in his basement back in 1952, it wasn't until the spring of 1958 that I became associated with him. At that time, he was able to demonstrate the feasibility of his high-voltage technique and it appeared to me that this could be an important breakthrough in radiation costs.

I might say Dr. Cleland's development of this accelerator was really remarkable. This was literally a basement development with no large Government laboratory or any laboratory at his disposal and very limited financial support. What support he did get came from a limited number of physicians, all of whom it turns out are constituents from Mr. Price's district.

The Dynamitron accelerator has now been brought to a commercial status and represents the investment of approximately $650,000 of private venture capital. We feel we have a great product and it is being actively promoted in a number of industrial areas.

The natural question in your mind is: "Well, fine, but what has this got to do with atomic energy?" Just this, our main competitor appears to be the Atomic Energy Commission.

At the beginning I wish to make it crystal clear that I don't believe this competition is due to a concerted effort on the part of the AEC to compete, but it is a natural consequence of a limited portion of its radiation development program. Certainly the remainder of the program to promote industrial applications of radiation is of immediate and long-range benefit to all.

We don't object to competition, if it is fair, but in this particular case we are at a definite disadvantage. For example, we are competing with an isotope technology subsidized in the main by the Government. I am referring to the technology of massive radiation sources.

With a public relations effort which has convinced the layman that radiation is synonymous with atomic energy and with future isotope cost estimates based upon questionable assumptions, it makes our sales task doubly difficult, for we have to dispel the erroneous impression of high radiation costs that most lay engineers have received from AEC announcements.

I stated my objections to this situation last year in a letter to the editor of Nucleonics; the same issue carried a reply from Dr. Paul Aebersold of the AEC. Subsequently a rebuttal by Mr. Alfred Burrill of High Voltage Engineering Corp. appeared in answer to Dr. Aebersold's letter. I should like to include this exchange of letters in my testimony this afternoon. Rather than read the exchange of letters in my testimony this afternoon, perhaps I can summarize them.

(The data referred to follow:)

NUCLEAR REACTIONS

A CASE OF STUNTED GROWTH?

DEAR SIR: That the application of radiation as an industrial tool is becoming of increased interest to both Government and industrial organizations goes without saying. However, as is often the case with a new technology, it is important that in its early growth nothing be done to stunt the growth pattern.

Unfortunately, I believe that such is the situation with regard to the AEC's position on radiation applications. In particular, I should like to direct myself to its position on massive radiation applications.

The long-term goals established for the Office of Industrial Development, namely, to develop markets for isotopes, fission products, and reactor energy, is commendable. Obviously, our infant reactor field would gain immeasurably if the waste products could be directed to practical uses. However, I believe that the method of achieving this goal bears careful scrutiny.

My contention is that in this field, as in all other economic areas, the law of supply and demand still holds. Consequently, the best and quickest way to achieve the long-range goal of the AEC is to help foster and develop the markets

and requirements for many kilowatts of radiation energy. Further, I believe that, having developed requirements for megawatts of energy, the AEC can step down and let American industry and ingenuity determine the best and most economic means of satisfying these requirements.

Instead, the AEC, through its industry development program, is trying to go the route of isotopes and reactors regardless of the practical economics today, tomorrow or even years from now. The end result, I believe, will be to the detriment of American industry and to the AEC's long-range goal.

If, as I feel will be the case, the programs now being sponsored by this agency result in ascertaining technical feasibility, but with the qualifying statement that the economics does not justify industrial application today because of high isotope costs, then many industrial engineers who might have been interested will shelve their projects awaiting the lower projected costs.

The end result will be to delay practical radiation applications and to shrink the potential demand for large quantities of radiant energy.

As a manufacturer of high-voltage accelerators, we naturally are concerned with this matter. Almost daily we have seen situations develop where radiation energy can play an immediate role if the cost is right. And for many applications, it can be proven that machine radiation is cheap enough today.

If the AEC wants to play a vital role in this field, let them support these practical programs and thereby develop immediate as well as future needs. But to offer support obliquely, prejudicing themselves in favor of isotopes and reactors, is to do a disservice to the radiation-application field. In addition, manufacturers like ourselves are put in a position of countering erroneous impressions regarding radiation costs that result from AEC emphasis on isotopes.

Further, since the AEC is a Government agency, whose activities are financed by all the taxpayers, why should they choose an arbitrary position that defeats their long-range goal and at the same time unfairly fosters a Government-supported competitor of accelerator manufacturers?

It is as if they ask us to help furnish the funds to bet on their horse in a horserace in which we have our own entry. Considering the lameness of their horse in today's race, the whole thing appears rather ludicrous.

KENNARD H. MORGANSTERN,
President, Radiation Dynamics, Inc.

[EDITOR'S NOTE: A reply from Paul Aebersold, Director, AEC Office of Isotopes Development, solicited by Nucleonics, follows.]

DEAR SIR: We welcome the opportunity to respond to Dr. Morganstern.

Dr. Morganstern questions the approach being followed in the Commission's program for developing industrial applications of high-intensity radiation. We consider this phase of the isotopes development program to be relatively long range and believe that radiation energy offers promise as a processing tool, as diverse in its capability as temperature, pressure, and catalysis.

The industrial radiation program is twofold. First, it is aimed at developing technology for radiation processes through research and development at AEC national laboratories and through contracts with industry and research oganizations. Second, this program is aimed at developing radiation engineering parameters, such as utilization efficiency, dose distribution and safety, related to the utilization of quintalcurie and megacurie quantities of radioisotopes for radiation processes.

Dr. Morganstern is in agreement with the first aim; i.e., the development of "markets and requirements for many kilowatts of radiation energy." Any advances in this area will, of course, be of benefit to the total radiation industry including machine manufacturers.

It would appear that Dr. Morganstern is taking exception to the second programmatic goal, the development of large radioisotope sources equivalent to 10's of kilowatts of machine power. Dr. Morganstern's point is that AEC attempts at developing engineering parameters of high-intensity radiation sources should include machine technology.

In this regard, it should be observed:

(1) The high-voltage accelerator industry has developed to its present advanced state partly as a result of use of such accelerators in Commission programs in chemistry, physics, biology, and medicine. This is a free competitive industry, although Government or Government contractors are major purchasers. In contast, high-intensity radioisotope sources for radiation processing are in an early state of development, and AEC is the sole U.S. producer. The AEC has a broad responsibility to develop peaceful applications of atomic energy.

It is the AEC purpose to bring the technology of high-intensity radiation applications up to a level that will permit the establishment of a free enterprise radiation production and utilization economy.

(2) Contrary to the implications of Dr. Morganstern's letter, high-intensity radioisotope sources are not competitors of machines per se. For some particular processes, it doubtless will prove true that only machines should be considered; in other instances high-intensity beta and gamma sources will be preferred for technical reasons such as depth of penetration, uniformity of treatment, more efficient source geometry and absence of induced activity.

(3) The economic situation is not as clearcut as Dr. Morganstern implies. Only hypothetical economic analyses exist comparing costs of radioisotope sources and machines. These comparisons do give machines the edge, but only in a broad sense, and not by orders of magnitude.

In summary, the AEC industrial radiation program will establish those conditions that will permit the normal growth pattern in the radiation industry that Dr. Morganstern advocates.

PAUL C. AEBERSOLD,
Director, Office of Isotopes Development,
U.S. Atomic Energy Commission, Washington, D.C.

NUCLEAR REACTIONS

A PARTISAN FOR PARTICLES

DEAR SIR: The recent letters of Drs. K. H. Morganstern and P. C. Aebersold (NU, June 1959, p. 6) have introduced a timely discussion regarding the relative usefulness of radioisotopes and particle accelerators for industrial processing. * * *

In the interest of clarity, I should like to comment on Dr. Aebersold's letter, in which he discussed three major contributions made by AEC to the broad field of radiation utilization.

(1) It is true that AEC has sponsored research in physics, chemistry, biology, and medicine, using high-energy particle accelerators. With very few exceptions, however (in fact, high voltage sales reflect no exceptions), these particle accelerators have been of the positive-ion variety or have been low-intensity electron machines for basic research. High-intensity Van de Graaff development has been sponsored almost exclusively by industry or through high voltage's own research program.

To the best of our knowledge, the resonant transformer and the Dynamitron developments have been similarly sponsored. Our knowledge of the linear-electron accelerator comes from extensive developments supported by Office of Naval Research. The programs currently being undertaken by the Army Quartermaster Corps and the National Institutes of Health represent two other Government activities not sponsored by AEC.

We can only conclude that, whereas AEC has indeed promoted the general field of particle acceleration, its contribution to low-cost, high-powered electron machines has not been significant.

2. We would like to take issue with Dr. Aebersold's comment that "high intensity radioisotope sources are not competitors of machines per se." In the fields of industrial radiography and cancer therapy, isotope sources are directly competitive with supervoltage machines in a most aggressive sense. Only the established low cost of cobalt 60 makes this competition possible. How realistic this cost is, as measured in terms of normal commercial practice, is conjectural.

In a powerful, indirect sense, the technical information released by AEC has tended to confuse the market and hence has caused deferment of many important projects. The exploitation of small cobalt sources for research has given a false sense of participation to a number of companies, despite the fact that these small sources offer neither the dose rate nor an approximation to industrial processing conditions that would make an extrapolation realistic.

3. We agree wholeheartedly with Dr. Aebersold that the economic situation is not clear cut, but we take issue with the reasons he gives. The economics of particle accelerators are well known today. These machines are sold on a fixed-price basis with firm costs of construction for industrial processes. The results are being proved in the field on a rather large-scale basis.

Based on our present knowledge and our demonstrated ability in the past to predict, new developments in particle accelerator techniques can be promised on a guaranteed basis. What clouds the situation is that the projected costs of radioisotope installations are hypothetical and incomplete, as seen by experienced designers of accelerator installations.

Equipment providing penetrating radiations at capital costs well below $10,000 per kilowatt are being quoted by us today for installation within the next few months.

Based on the equivalence of 70,000 curies of cobalt per kilowatt of ionizing radiation (this assumes an efficiency of isotope utilization much greater than can actually be realized today), the cost of cobalt would have to drop to 14 cents per curie to become competitive. It is doubtful whether this isotope could even be shipped from the nuclear reactor to the industrial installation for this amount. Furthermore, accelerator developments now under way in our plant can substantially lower current capital costs per kilowatt of radiation.

Our attitude with respect to the AEC Office of Isotopes Development should not connote our disagreement with their basic goal, that of developing widespread application of radioisotopes in science and industry. We believe that AEC is conducting an extremely important program in that direction. Our objection is that AEC is concentrating too much effort in an area already being served by a growing accelerator industry.

E. ALFRED BURRILL,
Vice President and Sales Manager, High Voltage Engineering Corp., Burlington, Mass.

Dr. MORGANSTERN. In my letter I pointed out that the long-range goals established for the Office of Industrial Development of the AEC, namely, to develop markets for isotopes, were commendable but I questioned the method.

Again I would like to point out that we are not questioning the wisdom of securing basic information on radiation nor the application of isotopes as tracers, but rather that limited portion the program which seeks to promote cobalt 60 as a method to be used for massive radiation applications. I feel that what we have here is an honest difference of opinion as to how on should go about developing a market.

Coming back to the letter, I felt that in order to develop a market for isotopes, a megacurie market, the practical economics of radiation processing would have to be proven out. And further, I felt that practical economics would come faster with machine radiation than with isotope radiation. Consequently, I suggested that the fastest way to achieve the long-range goal was to help develop those markets requiring many kilowatts of radiation power regardless of source; once the market was there, isotope radiation would find its proper place. Instead, I think we have a "dog chasing its tail" situation where the AEC is supporting engineering techniques for large sources, and the economic feasibility based upon large isotope production, but nowhere is there any development of tangible requirements for large amounts of activity.

I might say an analogy might be drawn between what I believe is going on here and with what happened regarding the small car and the Big 3 in Detroit. I believe that if the small-car market had not been stimulated by the import of small cars and the requirement not developed by these imports then Detroit never would have developed the market solely by issuing economic surveys indicating the cost savings that would result from using small cars. I think the need has to be there first. Then you have the market development, and the same situation applies with regard to the radiation processing field.

In addition, I felt that the results of many of the AEC's economic surveys are discouraging to many potential industrial users since they always seem to indicate economic feasibility some time in the future and only after a number of hypothetical things take place.

Dr. Aebersold's answer made three points:

1. The isotope technology was new, the accelerator field old, and AEC had already indirectly supported the accelerator manufacturers.
2. Isotope radiation is not directly competitive to machine radiation.
3. The economic situation is cloudy and not clear cut in favor of machine radiation.

In rebuttal, Alfred Burrill of High Voltage Engineering Corp. points out that:

1. The AEC has not supported high intensity electron accelerators.
2. Isotopes and machines are directly competitive in many areas.
3. The economic situation is cloudy only because the AEC's projected prices include many assumptions.

Whereas, accelerator manufacturers have firm prices on their machinery today.

Often, in justification for Co^{60} support it is pointed out (as in Dr. Aebersold's letter) that isotopes are new, whereas accelerators are old. I believe it is important to realize that the contrary is true. High power electron accelerators are only now beginning to reach the market, whereas large Co^{60} sources have been available for many years.

For example, you have a quarter million curie cobalt 60 facility at Cook Electric in Chicago, and it has been there for a number of years. As a result, the isotope technology is certainly as fully developed today as is the high current electron beam technology in the accelerator field.

Second, as Mr. Alfred Burrill states, the competition between Co^{60} and machine radiation is real and direct. For example, take the now defunct Stockton facility of the Quartermaster Corps; 2,500,000 curies of Co^{60} were programed for the facility.

Chairman ANDERSON. That is for food irradiation?

Dr. MORGANSTERN. That is correct.

Although, it was never clear to me who was to bear the cost of this material in today's market at $2 per curie for Co^{60}, the source would have cost $5 million. We are presently quoting on a 3.0-mev., 30-kw. electron accelerator which when converted to X-ray production, and I might say this conversion is an inefficient conversion because you lose 90 percent of your power, has a yield equivalent to approximately 450,000 curies of cobalt 60. Therefore, six of our machines would have accomplished the same task—at a cost of $720,000—a sevenfold saving. In fact, the replacement of cobalt 60 due to radioactive decay—approximately 12 percent per year—would pay for a new set of accelerators each year.

Chairman ANDERSON. Does that not have some bearing on this whole program of food irradiation?

Dr. MORGANSTERN. Very, very definitely. I think it would be woefully neglectful not to include machine irradiation. I am not talking about the linear accelerator of 20 million volts, but machine radiation converted to X-rays and thus directly competitive with cobalt gammas for the food irradiation program.

I will concede that there are some situations where cobalt 60 might be advisable, other than as a tracer, but they are few and far between and we have seen not a single one in our consideration of practical industrial applications.

As we see the picture, future Co^{60} costs will have to come down to approximately $0.30 per curie to compete with our X-ray costs today, and to $0.06 per curie to compete with electron beams of radiation energy output basis. And certainly, it is unreasonable to assume machine costs cannot come down also, as sizes and quantities increase.

We would like to find a requirement for a 100-kilowatt accelerator. We think it is completely feasible and its cost would be $2,000 per kilowatt. On this basis cobalt 60 would have to come down to 3 cents a curie. The AEC recently sponsored a research program with the General Nuclear Engineering Corp. to see what production costs would be entailed in designing a reactor to produce cobalt 60, the best cost estimate was $0.43 per curie as the basic production cost—not the sales price.

Why then this concentrated emphasis on cobalt 60 as the radiation source of choice for massive radiation tasks? There are commercial organizations with facilities available today for making cobalt 60, such as General Electric and Westinghouse. Certainly if and when there is a substantial market for cobalt 60, they would willingly develop the engineering techniques necessary to sell the cobalt 60 without Government assistance.

If, on the other hand, the AEC deems it of national importance to see radiation processing grow rapidly, then I would respectfully suggest that support be given the following.

One, the high-intensity radiation laboratory which is being programed at Brookhaven should include machine sources as well as cobalt 60 in order to get a well-represented view of all sources of radiation. I now understand this is being programed, although it was not so indicated in the latest AEC announcements.

Two, the food preservation program when it gets off home plate should include machine sources as well as cobalt 60.

Again I would like to stress I am talking about machine sources in which you have converted to X-rays and you have an equivalent type of penetration to that from cobalt 60 gammas.

Three, radiation technology as an engineering field should be supported, as is reactor technology, by setting up academic programs in engineering schools and providing the schools with radiation laboratory equipment which can simulate "on stream" industrial use. It seems to me we have a goodly number of reactor courses and very soon we are going to have a goodly number of reactor engineers, and I doubt if we will have enough reactors going in this country to satify them all. I honestly think there will be a more pressing need for people who have been trained as radiation engineers, and to date there is no program in existence in the country that I know of.

Fourth, areas should be sought where, with a slight lowering of cost radiation, processing can be proven practical and let this help to be the "lead dog" to widescale industrial use even if the radiation processing involves machine radiation rather than isotope radiation.

In closing, I would like to say, as I indicated at the beginning, that many of the present AEC contracts are of immeasurable value since they are producing basic information on interaction of radiation with matter. We as accelerator manufacturers certainly welcome this fund of information.

Gentlemen, again my thanks for inviting me to testify.

Chairman ANDERSON. Thank you for being here.

Dr. Aebersold, I would appreciate it if you would submit some comments on this statement. I would like to have some comments on the food irradiation because I have been very anxious to see that program go on, although not in charge of the Army.

Dr. MORGANSTERN. I agree with you. It has been awfully discouraging to us. We were talking to three separate governments and it is our own personal feeling that food preservation will come faster outside of this country than in this country because of lack of refrigeration in underdeveloped countries. These were three countries very excited about the prospects, and all three of them have cooled off considerably because of this fiasco with regard to the Quartermaster program.

Chairman ANDERSON. It is very desirable to correct that as fast as we can.

We will resume at 10 o'clock tomorrow morning.

(The comments referred to above follow:)

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., March 25, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy, Congress of the United States.

DEAR MR. RAMEY: At the February 18 session of the 202 hearings, we were asked by Senator Anderson to submit comments on the statements of Kennard H. Morganstern, Nuclear Consultants, Inc. Such comments are set out below.

It has been suggested that because machines are commercially available and radioisotopes are not, and because machine radiation power costs are lower than isotope power costs, the Commission should not pursue isotope source technology development. Such a suggestion presumes that machine and isotope sources are directly comparable and are competitive.

Comparison of machine and radioisotope sources cannot be readily made without certain technical considerations. These are:

(1) depth of penetration of radiation;
(2) uniform radiation of large packages;
(3) dose rate;
(4) throughput; and
(5) activation of product being irradiated.

Gamma and X-radiations are much more penetrating than electron or beta radiations. Therefore, gamma emitting radioisotopes such as cobalt 60 and cesium 137, have much higher penetration characteristics than machines. Machines can be used to produce X-rays. However, the efficiency of conversion of electronics to X-rays is only about 10 percent at the energies usually considered for machines. At high electron energies where X-ray conversion efficiencies are greater, it is theoretically possible to induce radioactivity in target materials.

Low penetration of electrons and beta rays is advantageous for treatment of thin materials because then most of the energy is usefully absorbed in the product.

Uniformity of radiation can be achieved with electron machines through beam scanning techniques and with isotopes through construction of extended sources.

Large radioisotope sources deliver dose rates about 10^3 or 10^4 times lower than delivered by machine sources. For certain radiation processes, low dose rates are known to be necessary because the chemical reaction occurring is dose rate dependent.

For low throughput, low dose processes, machine sources may be technically unfeasible because of control problems due to very high dose rates and short dwell times in radiation fields. Minor fluctuations in conveyor speed may result in a high rejection rate.

The activation of irradiated materials is possible with high energy electrons with some of the X-rays they produce, and also with certain radioisotopes having high energy radiation. Cobalt 60 and cesium 137 are safe from this point of view.

Besides the technical factors already discussed, one must consider economic ones. The usual comparison of machine and isotope sources ignores technical factors and considers only cost per kilowatt-hour. Such a comparison, without reference to efficiency of design and operation and process technical requirements, is virtually meaningless.

A study prepared for the Commission in January 1960 estimated the following operating costs for machines and radioisotopes:

[Cost per kilowatt-hour]

Source	3 kilowatts delivered	30 kilowatts delivered
Cobalt 60	$8.70	$2.95
Cesium 137	10.50	4.35
Machines (1.5 to 3 Mev.)	7.75	1.70

Cost for all of these sources may be expected to decrease.

Machines are least expensive on a cost per kilowatt-hour delivered basis, but for a process requiring deep penetration, for instance, either electron energy would have to be greater than 3 Mev., which increases cost per kilowatt-hour, or electrons would have to be converted to X-rays which, at only 10 percent efficiency, increases cost by a factor of 10. Obviously, taken out of context, these costs have little significance. Given the technical requirements for any particular process, it is clear that each radiation source will have to be evaluated independently.

It should be noted that millions of curies of radioisotopes will be produced in the foreseeable future. The Commission, through the Office of Isotope Development and its industrial process radiation program, is attempting to find ways to put this huge radiation power resources to work.

Heretofore, a few radiation applications, such as crosslinking of polyethylene insulation to improve its thermal stability and sterilization of sutures, have achieved commercial feasibility. These mostly employ electron machines as sources of ionizing radiation energy. This does not mean that these machines are necessarily superior to cobalt 60 and fission products because:

(1) technology of fission product sources is not adequately developed;

(2) sufficient processed fission products for industrial radiation process research and development are not available; and

(3) present costs of fission products are high.

The Commission is the only producer of separated fission products in the United States. Therefore, it has responsibility for developing the technology for fabricating and using such sources. The Commission has the same responsibility in regard to cobalt 60 since cobalt 60 is an interim radiation source necessary for research and development purposes until separated fission products are available in full supply. Research and development necessary for design of large cobalt sources for pilot plant and demonstration uses is the Commission's responsibility.

The present U.S. capacity for processing fission products is low. It would take over 2 years of continuous operation of the fission products pilot plant to produce cesium 137 equivalent in power to 100,000 curies cobalt 60. It would take 25 to 30 years to accumulate enough cesium 137 to equal the power output of a 15-kilowatt electron machine. Such a machine can presently be purchased as an off the shelf item from any one of several private companies.

Sincerely yours,

R. E. HOLLINGSWORTH,
Acting General Manager.

(Whereupon, at 5:10 p.m., Thursday, February 18, 1960, the hearing was recessed to reconvene at 10 a.m., Friday, February 19, 1960.)

DEVELOPMENT, GROWTH, AND STATE OF THE ATOMIC ENERGY INDUSTRY

FRIDAY, FEBRUARY 19, 1960

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
Washington, D.C.

The committee met, pursuant to recess, at 10 a.m., in room P–63, the Capitol, Senator Clinton P. Anderson (chairman of the Joint Committee) presiding.

Present: Senators Anderson and Aiken; Representatives Holifield and Hosmer.

Also present: James T. Ramey, executive director; and George F. Murphy, Jr., professional staff member.

Chairman ANDERSON. This morning the Joint Committee is meeting to receive testimony from witnesses from industry on the development, growth, and state of the atomic energy industry.

Our first witness today is Mr. Pofcher. I am sorry we could not take you yesterday afternoon and we appreciate your coming back this morning.

STATEMENT OF MUNROE F. POFCHER, PRESIDENT, RADIATION APPLICATIONS, INC., LONG ISLAND CITY, N.Y.

Mr. POFCHER. Thank you, sir.

My name is Monroe F. Pofcher. I am president of the Radiation Applications, Inc., in Long Island City, N.Y. I appreciate this opportunity to appear as a witness in connection with your consideration of the AEC's program of isotopes and radiation development.

Radiation Applications, Inc., is a research and development company organized in December 1954 primarily to develop industrial applications of radiation energy. From 1 full-time employee in 1956 we have grown to more than 50 scientists and technicians; of this number, some 20 people are directly involved in radiation processing and radiation source technology.

Our company performs contract research and development for industry and for a number of Government agencies, including three contracts with the AEC's Office of Isotopes Development. In addition, we currently devote all available funds from operating income and from invested capital to support our own research, most of it in the field of radiation processing.

As I will discuss briefly in a few minutes, our company is now marketing one result of this research, the first industrial product involving radiation grafting, and is readying for market several other irradiated products.

Perhaps as well as any other group, we are familiar with both the potential of radiation processing and with the problem of going from the test tube to the production line. We live with this every day of the year. We have, therefore, studied closely the program of the AEC's Office of Isotopes Development and have considered carefully the proper and logical role for the Federal Government in the isotopes and radiation field. I should like to share our conclusions with you.

Let me make it clear at the outset that we are not involved with the use of isotopes as scientific and industrial tools; that is, as tracers, gages, and quality control instruments. We are directly concerned with using the energy of large quantities of radiation, thousands, eventually millions, of curies, for purposes of industrial processes, specifically to initiate productive and important chemical reactions. This is a separate area to which the AEC, under OID's industrial process radiation program, is also giving primary attention.

Some indication of achievements to date and the possibilities of radiation processing in the future will, I believe, be helpful. Radiation processing has already opened up a new class of high-temperature-resistant plastic materials vital for use in the electronic and missile fields; a number of these materials are currently being sold and others are being developed. Many other reactions which are possible in the future can be of great significance to our national economy. Think, for example, of the economic advantage to our Nation should radiation processing convert coal into valuable new chemicals and so develop a whole new market for this natural resource. Think of the benefits which would accrue if new types of chemicals and plastics with superior properties were produced, if radiation processing were to give long life to wash-and-wear fabrics whose principal drawback now is that their finishes are not permanent, if heat-sensitive plastics could be cured and rubber-vulcanized on an industrial scale by radiation processing. Think what a boon radiation preservation of foods can be in certain underdeveloped areas of the world.

With these possibilities in mind, I would like, if I may, to make these three points to you:

1. Although the potential is great, radiation processing is still in its infancy and industrial processes in this country are still largely in the future. Other countries, as I will discuss, are ahead of us.

2. The radiation applications that have been achieved are the result of long-term research programs, some extending over many years. This is not a short-term, quick-profit business.

3. The success achieved in the use of isotopes as tracers, gages, et cetera, should not be permitted to obscure the needs of the radiation processing program.

What are these needs?

Essentially, we believe that the proper and logical role for the Federal Government to play is to support developmental research in radiation processing; that is, to assist in developing a real understanding of the mechanisms and techniques of using massive quantities of radiation energy for peaceful purposes. This is the area prior to product research and engineering. Industry can afford to and should do product research, but if left alone to close the gap between basic research and engineering of products and processes, there will

be a serious time delay which we believe will be detrimental to the national interest.

In short, we urge that the Congress assure that fully adequate support, and of the proper type, be given to the industrial process radiation program, and that administrative budgetary pressures not be permitted to impede the program.

I think there are two questions I should answer for you:

(1) Why should Congress do this?

(2) Specifically what type of support is needed?

As to the first question, radiation processing is a field that the atomic energy program opened up and has made possible. Although still new, there is perhaps no other area where a relatively modest investment gives such promise of return to the public in terms of improved products, new materials, and new processes. Atomic radiation is one of the most powerful initiators of chemical reactions ever discovered. It would be a pity if lack of Government support, at a level of perhaps less than 1 percent of the money spent on the nuclear power program, delayed the achievement of this promise.

We believe it is in the national interest that this country keep pace industrially with other countries; indeed, more, that it is essential that we be in the forefront of industrial progress. Radiation processing offers a splendid opportunity along this line.

I have already indicated some of the possibilities. Other countries also are recognizing the possibilities. Indeed, from recent international conferences it has become painfully apparent that they are devoting a much greater proportion of their atomic energy budgets to radiation processing than we are. The British have already built much larger cobalt production devices than we are currently planning for a number of years in the future. The quality and quantity of work in Russia in the utilization of isotopes, as recently reported by Russian scientists at various meetings and conferences, is in some respects already more advanced than our program, and is being accelerated. Indeed, they are reporting pilot-plant data and the construction of radiation production facilities while we are still talking about test tube experiments. We are in serious danger of being second best. Japan has an active program in irradiation of textiles and Australia has a cobalt irradiator larger than any in this country, for the destruction of anthrax. These are only a few examples.

Now, why doesn't industry do the job if the potential is so great? Let us be clear about this. Industry is doing a job. As I have indicated, my company is spending a great proportion of our limited funds on radiation processing research. Other companies are spending larger sums of money. But there are two problems.

The first is that we are dealing with a new field of great promise and many problems, and, just like in the nuclear power program, a considerable amount of long-range development is required. There are large gaps in our knowledge of basic mechanisms and techniques. Helping to fill these gaps is, we believe, a proper role of Government in a new and dynamic technology.

The other problem, in our opinion, is that the potential of radiation processing is still not well understood by large segments of American industry. The word "radiation" is a fearful word to many; it is associated with the "magic" of atomic energy. We want the Office

of Isotopes Development to help give the field a running start, to act as a catalyst, to make sure that the important gaps are being filled, until industry can take over fully. This, too, we believe is a proper role for the Government. And when you are performing a catalytic function, a relatively small amount of money can go a long way.

Now, specifically, what should be done in the industrial process radiation program?

As I have indicated, the need is for developmental research in the important fundamentals of radiation processing and source technology. I mean by this that we must learn how to use radiation energy and also that we must develop inexpensive, efficient, and safe radiation devices to give us radiation energy in a form we can use.

Let me explain this last point briefly.

The important sources of ionizing radiation are fission products, reactor-produced isotopes, nuclear reactors, and machine accelerators. The first three are in the AEC program, and, insofar as they are useful for radiation processing, are the direct responsibility of the Office of Isotopes Development.

Now, as you know, you just can't take fission products as they come from a reactor and use them for radiation processing. They must be separated, preferably during fuel processing when you can do it cheaply, and then fabricated into solid forms for use as irradiators. Much more work is needed on the development of efficient and economical systems for separating and extracting isotopes, and then incorporating the isotopes in devices suitable for processing large volumes of material on an industrial scale.

In this connection, I want to point out yet another reason why the Government has a real and valid interest in helping assure that radiation processes and isotopic devices or irradiators are developed.

The atomic energy military and power programs assure that billions of curies of fission products will be produced in the foreseeable future, whether or not they can be used. In this context, the Atomic Energy Commission is in a position similar to a company with a potentially valuable byproduct material. The company will, to the fullest extent necessary, support research to find uses for that byproduct so it can be sold.

A few moments ago I mentioned machine accelerators as sources of radiation. These are manufactured by private companies. There has been some discussion of competition between isotopes and machines and some question of the advisability of Government support in certain areas where private companies are operating. This, we feel, is a "red herring." Machines and isotopes must not be viewed as being necessarily competitive. They both have their place. Different processes will require different sources of radiation.

For example, we have found in our own work that a machine is preferable to irradiate polyethylene plastic wire insulation (to improve its thermal properties), but that cobalt is preferable to irradiate fluorocarbon wire insulation (to improve its bondability).

Once large beta irradiators, such as strontium 90, are developed, they will likely be best for certain processes involving surface treatment of materials.

It is to the interest of the machine manufacturers that the research which will lead to applications of radiation be performed. It is to the

interest of the radiation user that the right kind of irradiator be developed for each particular application.

My remaining point has to do with the research necessary to lead to peaceful applications of radiation energy.

As I have indicated, this can best be described in general terms as developmental research, or learning as much as possible about the whys and wherefores of radiation energy and the basic mechanisms and techniques of radiation processing.

I want to outline briefly a case in point.

One of the most exciting applications of the use of radiation energy is to utilize that energy to "graft" a new surface, similar to a botanical or skin graft, to an existing plastic so as to retain the desirable properties of the original plastic, while giving the resulting new material the additional benefits of the properties of the new surface. This is called radiation-induced graft copolymerization.

Our company has introduced the first industrial process involving the radiation grafting of plastics, our Raibond process for increasing the bondability and printability of fluorocarbon plastics. Fluorocarbon plastic materials produced by the Raibond process are now being used as wire insulation in electronic systems, as waveguide windows in radar systems, as covering for radomes in missiles, and in a number of other defense applications.

We have also utilized this process to develop special membranes in such diverse fields as water desalination for the Office of Saline Water and battery separators for the Army Signal Corps.

Now, although we have been working on this process for some 2 years, we still have difficulty in reproducing our results and otherwise finalizing the process variables and parameters. The reason, simply, is that we know so little about the basic mechanisms of radiation grafting, why the reactions take place, how the radiation energy can best be utilized.

This is the type of developmental research a small company such as ours cannot support in the manner in which it should be done, to give the answers which would be of use not only in our work but to many other companies throughout the country and throughout the world. In short, we need to know much more about the underlying principles of applied radiation chemistry.

I have not made any particular reference to the food radiation-preservation program. This subject has been adequately covered in other hearings. I do, however, want to point out one problem which, if not carefully thought through, may seriously impede the program of the Office of Isotopes Development. There is the likelihood that OID will be called upon to administer some part or all of the proposed civilian food irradiation program. Thus far, there is no indication that additional funds will be provided for this project. If this occurs, present programs will of necessity be cut back even further, and the present level of support is already so low that it is not now possible to follow up effectively the excellent research currently being performed by various universities and industrial laboratories under OID sponsorship.

In summary, we believe that radiation processing offers perhaps the greatest challenge and opportunity we presently have to utilize atomic energy for peaceful purposes and for the public benefit. We will

regret it if we are not the first to meet this challenge. And we may not have such an opportunity again.

I want to thank you very much for the privilege of appearing here and for your courtesy and attention.

Chairman ANDERSON. I want to tell you that I think that was a very sincere and thoughtful presentation. In our hearings next month we are going to be discussing the frontiers of atomic research and development, and we plan to deal with this radiation process chemistry. If you have any suggestions as to how we might deal with it best, we would be very glad to hear you.

Mr. POFCHER. Thank you very much. We would like very much to participate at that time.

Representative HOLIFIELD. I also want to say you have given us a very thought-provoking statement. I was somewhat surprised when I read your statement there that other countries are going way ahead of us in this field, such as Russia and Japan. They are doing more. That is a pretty well-considered statement, is it? Do you have quite a bit of information or evidence to support that?

Mr. POFCHER. I believe so, sir. I did not mean to imply that they are necessarily away ahead of us at this point. What I did mean to imply is that they appear to have more active programs. If present indications hold, it is likely that they may get ahead of us in the not-too-distant future.

Representative HOLIFIELD. In your handling of your isotopic sales-work to different industrial companies, have you found that the disposal of waste materials is a factor of considerable economic importance?

Mr. POFCHER. I think I know the problem to which you are referring, Mr. Holifield. This is not a problem we have.

Representative HOLIFIELD. Your type of instruments and your processes do not necessarily generate waste material?

Mr. POFCHER. That is correct. As I tried to indicate, we are not involved with instruments or the use of isotopes for purposes of tracers, gages, et cetera. We are directly involved with using radiation energy for purposes of industrial processes.

Representative HOLIFIELD. On plastics and different materials?

Mr. POFCHER. Plastics, chemicals, and different materials.

Representative HOLIFIELD. Were you in the food preservation program by subcontract?

Mr. POFCHER. Yes. We did some work in the food preservation program. We had a subcontract with American Machine & Foundry which involved a fairly large program to irradiate potatoes. We did some other minor work in the general field of food preservation.

Representative HOLIFIELD. Apparently the Army Quartermaster Corps has been given orders to practically close this thing down. That is where most of the money was coming from for the preservation of foods for military purposes. It appears that they put a committee in study of that headed by a man who has been interested in frozen foods, and he came up with the customary verdict which most any group would. The railroads will come up with the same kind of verdict against airlines or the trucking industry.

Mr. POFCHER. If I may say, Mr. Holifield, we think that there is great potential in the radiation-preservation-of-food program. We think a great deal of basic research and developmental research needs to be done. We think the research should be tied in as much as possible with the actual industrial processes that are now being used in the food business. An example of that is that we found in our work with potatoes, radiation had a very beneficial effect. But when you tried to apply the radiation in the kind of handling that potatoes are subject to in normal potato handling in the potato industry, the radiation prevented the potatoes from sprouting, but they sure rotted. The potatoes were subject to rot.

Representative HOLIFIELD. Did the radiation cause that?

Mr. POFCHER. We don't believe the radiation itself did, but apparently the handling of potatoes, as I understand it, in normal commercial channels subjects the potatoes to very severe pressures. One problem we had with the program is that we felt not sufficient thought was given to using radiation in view of the kind of handling that the foods are subject to in the normal course of food handling. What I am trying to suggest really is that along with research into the use of radiation for food preservation, we need further study of the use of radiation in the light of actual industrial handling practices.

Representative HOLIFIELD. In other words, where to apply that radiation and what process in the field to market chain handling that you could most economically and practically apply.

Mr. POFCHER. That is correct, sir.

Representative HOSMER. I think you spoke of the necessity of increased radiation grafting research. Where did you have in mind that it would be done? In the national laboratories or by contract to firms such as yours, or how?

Mr. POFCHER. I think, Mr. Hosmer, I can answer that question by saying that this type of research is now being done at universities, at industrial laboratories, and at national laboratories. I don't have any figures indicating what the breakdown is, but I see no reason why that type of research should not continue to be performed at universities, at national laboratories, and industrial companies.

Representative HOSMER. It is now being performed. Your recommendation is that it be intensified.

Mr. POFCHER. That is correct, sir. As I have indicated, work is being done, but we think it is not being done and supported at a level which is appropriate in view of the very real promise we feel the field holds.

Representative HOSMER. You mentioned that installation in Australia. Is that a pest-control type of device?

Mr. POFCHER. I believe so. It is a large cobalt irradiator used primarily to destroy anthrax in goat hair.

Representative HOSMER. Is that similar to the work we have done with flies and worms, and things like that?

Mr. POFCHER. I think it is generally similar.

Representative HOSMER. You have characterized the competition between the isotope sources and the mechanical accelerators as a red-herring sort of thing. Is that your own opinion? I don't think the mechanical accelerator people share that opinion at this point, do they?

Mr. POFCHER. As I understand the position several of them have taken, they feel there is some question that the Atomic Energy Commission should support research in the development of isotope sources for radiation processing on the grounds that their machine accelerators can do the same job better. We feel that this is not so. We feel that machine accelerators are preferable for certain types of applications. In fact, we have just within the last week concluded arrangements to lease an accelerator from one of the machine accelerator companies.

Representative HOSMER. In other words, what you have said here is in the nature of a warning, as I listened to it. I wanted to make sure whether or not it reflected what the industry generally feels. You are pointing to an enlightened course.

Mr. POFCHER. I think people who are trying to use radiation energy for purposes of processing believe the same thing we do, that machines have their place and isotopes have their place. In some areas, they are competitive. In many areas, they are not. For example, we cannot use a machine to treat the flurocarbon plastics. The machine just won't work. On the other hand, for purposes of irradiating polyethylene wire insulation, present cobalt source technology is not good and the machine is much better.

Representative HOSMER. The point is that there is a flexibility here. One or the other may be the best for a particular job.

Mr. POFCHER. That is correct.

Representative HOSMER. It will help both the natural sources and the machine sources.

Mr. POFCHER. That is right, sir.

Representative HOSMER. There is just one other thing I would like to ask about. This Raibond process of yours; is there any other country that actually is doing this type of thing industrially?

Mr. POFCHER. We do not know of any, sir.

Representative HOSMER. At least, we are ahead in that field?

Mr. POFCHER. I think we have made very good progress in this field. The reason that no other country may be doing it, however, is not necessarily due to our progress. It is due to the fact that we probably use more material of that kind, more plastic material of that kind than any other country does. This process is particularly suitable for fluorocarbon plastic material. These are such things as Teflon made by Du Pont.

Representative HOSMER. As a matter of fact, outside of the plastic field in most chemical processes irradiation has not yet received any particular attention.

Mr. POFCHER. I think most of the more immediately promising industrial applications are in the plastic field.

Representative HOSMER. For instance, you don't see any possibility of use in making cement?

Mr. POFCHER. The Russians have announced that they are building a cobalt facility to make phenol. They are also using radiation for production of certain chemicals. Frankly, we have some doubt that they are quite as far along as they have indicated. From the data we do have they certainly are working actively in this field, and in certain respects they have good data.

Representative HOSMER. The applications appear to be in the more sophisticated field of chemistry.

Mr. POFCHER. I hesitate to agree fully with that, sir, because I don't know what you mean by the sophisticated fields of chemistry. In terms of actually producing large-volume bulk chemicals through the use of radiation energy, I would guess this is sometime in the future. Just how long will depend on how active a program we have and the relative economics of radiation processing as opposed to other types of processing. But certainly we can already see many potential uses for radiation, as I have indicated, and we feel that what is primarily needed is an acceleration of the developmental part of this program so that we can begin to take advantage of some of these possibilities as soon as possible. I dont' have the exact figure of how much money the industrial process radiation program of the Office of Isotope Development is currently spending for the type of research I have outlined, but I am fairly sure it is well under a million dollars a year. It seems to us that this is a very, very small sum of money to be spent in a field that has the kind of promise radiation processing does.

I am not competent to give you an exact figure of what should be spent, but it certainly seems to us that a 50-percent increase or a doubling of the effort in view of the kind of money that we are talking about is certainly warranted, particularly when you consider the possibilities of radiation processing for industry in this country and throughout the world.

Representative HOSMER. Thank you.

Chairman ANDERSON. Thank you very much.

Mr. POFCHER. Thank you, sir.

Chairman ANDERSON. The next witness is Mr. Spector.

STATEMENT OF DR. NORMAN A. SPECTOR, VITRO CORP. OF AMERICA

Dr. SPECTOR. My name is Norman A. Spector. I am a vice president of Vitro Corp. of America. We appreciate the opportunity to be present at these hearings and to express certain of our views on various aspects of the development, growth, and state of the atomic energy industry.

I would like to comment, first, with respect to the civilian power reactor program.

There has been too short a time between the release by AEC of their 10-year plan and my appearance before this committee to give adequate consideration to the many facets of this program as it is now defined. However, even from a brief review, it is evident that there is much in the announced program which deserves our complete support.

We feel the Commission is to be commended for their solicitation of expert advice in evaluating the potential of the various reactor concepts and in recommending programs to accomplish the potential improvements. This program has defined specific research and development tasks as well as prototype and large plant construction projects. In presenting their program along these lines, together with their best estimates of schedule requirements and costs, we be-

lieve that AEC has perhaps for the first time clearly defined the national objectives of our civilian reactor program in the framework of specific milestones along the path that they believe leads to competitive nuclear power.

It is almost impossible to challenge the technical programs in the light of our present knowledge—except perhaps to recognize the hazards of estimating schedules and costs in a field which will move so rapidly over this period of time.

Specifically, we are pleased to see the inclusion in this program of concepts which we have repeatedly urged such as the gas cooled and natural uranium reactors as well as the uranium-thorium, plutonium, and thorium breeding cycles.

In past testimony we have urged the consideration of thorium cycles, feeling that the tremendous reserves of this nuclear fuel could not be ignored in any proper consideration either of potential economics or from the standpoint of fuel reserves. While the ultimate role of thorium cycles is not readily apparent in any reasonable detail from the long-range program, we are gratified to find that thorium will be used in five reactors either being built or planned, and consider this significant progress in this direction.

Chairman ANDERSON. Do you know if the Atomic Energy Commission pays anything for the thorium that happens to be in the ore?

Dr. SPECTOR. To my knowledge, the Atomic Energy Commission does not pay for thorium that is incidental. In fact, it is quite the reverse. We have been paid for uranium recovered from thorium ore. However, my knowledge of this is limited. I believe that the specific purchases in this category are probably limited, so that the statement is not general.

Chairman ANDERSON. I just wondered, if thorium is so valuable, why the Atomic Energy Commission says if you have some thorium in this ore, stack that on the outside: we don't pay for that.

Dr. SPECTOR. I am not aware of any thorium that comes along with uranium ores as we mine them or as others mine them. Usually it is a trace amount of uranium that comes along with a thorium ore, monazite, for example. In this case the Commission says the uranium is so valuable you stack it up alongside, and we will buy it. This is, of course, particularly true in France, where the thorium constitutes a very large percentage of the uranium in the concentrates.

We are already aware of some preliminary reaction to the AEC's program, which questions the fact that only two developmental reactors are scheduled for construction in the near future. We would urge that, if consideration is to be given to increasing the number of reactor experiments or prototypes scheduled in the early part of the program, consideration to be given to advancing the present plan to develop thorium concepts.

The costs of this program are estimated as above $1 billion for research and development and about $1.2 billion for construction. This latter figure could be cut approximately in half by industry participation. When viewed over the period of the program this would appear a reasonable price to pay to reach the stated objectives. We do not agree that it should be necessary to spend more and it may well be possible to spend less.

There is reason to believe that both the pressurized-water and boiling-water concepts will soon take another major step forward to competitive power by projects to be carried out with minimum cost to AEC. In addition, it seems to us that, if there is compelling reason to reduce the costs of this program, aqueous-homogeneous and heavy-water concepts should be reexamined. Using AEC's own planning figures, these represent $169 million for research and development (or more than 15 percent of the research and development total budget) and $292 billion for gross construction costs, which is 25 percent of this total budget. With the completion of construction of major units of these types presently estimated as coming no sooner than January 1969 and January 1970, it is probable that the operating experience to be gained from this entire part of the program will still be inconclusive at the end of the 10-year program. In view of the fact that the potential generating costs from these concepts are well above the economic objectives which have been set for this program, this area of development seems a natural target for budget cuts. Indeed, we wonder if AEC, in developing the plan for these concepts, has not succeeded in developing a case for leaving them out.

THE ROLE OF INDUSTRY

AEC has defined its policy in carrying out their announced program by stating that reactor experiments should be built and operated by AEC; that prototypes should be built by industry independently or in cooperation with AEC—alternatively by AEC; and that large stations should be built by industry.

Basically, we are in substantial agreement with this policy statement and feel that AEC should have the prerogative of proceeding on their own with prototypes if industry is unable to participate in such developments on the time schedule required by the AEC program.

However, we feel just as strongly that the development of a capable competitive nuclear industry requires that this industry have the opportunity to participate fully in the program. It must be permitted the opportunity to "learn by doing" just as AEC itself in its own installations has developed increased capability of facilities and staff.

Chairman ANDERSON. Do you feel that the industry has had an opportunity to participate? There have been various instances where there has been a long-drawn-out negotiation running a couple of years trying to get industry participation and we have lost valuable time. Some of them might just as well have gone ahead and built something.

Dr. SPECTOR. I think, to answer your question, I would state without too much second thought that, of course, there has been a chance to participate. I think, however, some of us feel that the time has come to accelerate the rate at which industry is participating, and that there come from time to time instances which make us wonder whether the policy is being implemented in accordance with its definition.

Chairman ANDERSON. Consolidated Edison started out to spend $55 million, and it is up over a hundred million. Do you think they will push forward for a chance to participate or will they rest for a while?

Dr. SPECTOR. I think they are perhaps entitled to a rest.

Chairman ANDERSON. Don't you think there are a few others in the same category who might take it a little easy for a while when they discover the cost of these plants?

Dr. SPECTOR. I think there are undoubtedly those who will now take a closer look at what is involved in trying on their own to break some new ground and perhaps in the Consolidated Edison case it was not fully appreciated how new the ground was.

Chairman ANDERSON. This is partially a thorium device, is it not?

Dr. SPECTOR. That is correct. The objective should be for AEC to contract with industry for the types of work which will help prepare industry for assuming the eventual task of continuing development in the years ahead. I refer here to evaluation projects, engineering, research and development, as well as requirements for materials, products, and reprocessing services. We would welcome an attitude on the part of AEC that recognizes this policy and clearly reflects an obligation to seek even more aggressively than before the ways and means of accomplishing their program by industry contracts rather than in expanded AEC facilities.

Mr. RAMEY. Going back to your figures on the 10-year program, what are those figures based on? Are those from part 2 of the AEC report, or from their testimony the other day?

Dr. SPECTOR. I have neither heard nor seen the testimony. They are based on the part 2 information which was sent out with a press release and received just the early part of this week and held for further release until Tuesday on which date I think the testimony was given.

Mr. RAMEY. That would be the amounts of money to achieve the optimum development of each concept.

Dr. SPECTOR. This is correct.

Mr. RAMEY. The other day, or the first day of the testimony, we got into a bit of confusion over those figures and the figures that AEC prepared for us on their actual projected program that they are recommending for the next few years, which is different from this optimum program that they outlined in part 2. So Senator Anderson requested that the Commission staff and the Joint Committee staff get together and try to figure out an understandable comparison of these figures so that we would know a little bit more about them. I think if you look at AEC figures on both the optimum and on their 10-year program that they have quite a slug of money in there for fast breeder development, which is another one of these developments that would be a natural for the budget cutters if they were going to consider cutting, rather than adding on. As you know, on your heavy-water development, there are quite a few people that dispute some of the figures, that they may be downgrading the heavy-water, natural-uranium concept due to certain aspects of financing in this country and other things that might make them look bad compared to the enriched reactors.

Dr. SPECTOR. If I might comment on both of the remarks you made, I am certainly happy, and it is not unexpected that the Joint Committee has moved far more quickly than some of us in suggesting that some of the conclusions are not quite in accordance with the facts. This was really my point. I have my own opinions in some

areas with respect to the particular definition of the status and the promise of a given reactor concept, but that was not my point.

Representative HOLIFIELD. You say that the 10-year program as outlined by the AEC will be inconclusive in its results. This means to me that you feel that they will not reach the goal of economic power which they think they will reach, or near the goal.

Dr. SPECTOR. No, sir. I think what I tried to say was that with respect to those two particular parts of the program, namely, the aqueous-homogeneous and the heavy-water concept, the schedule that AEC projects at end of construction for the large power stations carried along under those parts, using their figures, are, respectively, January 1959 and January 1960. My point is simply that I am sure that the facts of life are such that, with these types of projects we have in mind, there is liable to be some slowing down, and still you don't get experience when the plant is just built. The operating experience will come only in the next year or two. Again I am sticking to the ground rules. I am saying under their ground rules they will not at the end of their program have proven much about these types. That is more the point.

Representative HOLIFIELD. Do you think there is another way they can approach this so that they will get to their objective quicker?

Dr. SPECTOR. I don't stand ready at the moment to suggest a faster route.

Representative HOLIFIELD. Would you suggest that they do away with that line of experimentation?

Dr. SPECTOR. Exactly, under the present ground rules.

Representative HOLIFIELD. And stick to the pressurized-water and boiling-water concepts? Is that what you mean?

Dr. SPECTOR. Generally, yes.

Representative HOLIFIELD. In other words, you just don't believe in those types of reactors?

Dr. SPECTOR. Not if these figures are correct. I think they have defined some ground rules. If they start skirting the edges of these ground rules and make exceptions the whole program is going to start to come apart at the seams, and we will be right back where we were several years ago. I prefer to keep these ground rules if they are acceptable to all. If the ground rules indicate that something will not come along and be competitive in 10 years, I see no justification for including it in this program. Under the approach of other countries, where they have 5-year programs and 10-year programs, it is almost invariably a fairly sacred task and sometimes when they would like to do another type of project, they clearly define it as being outside that program. Perhaps we could keep this 10-year drive for economic competitive power clearer and avoid a lot of criticism if we would say these two don't fit. But if you fellows all agree that we ought to be doing some work in the other areas, then do some work. Put them off to the side and put a special label on them and we won't get into bad arguments.

Chairman ANDERSON. In other words, you put the fire under the thing that shows promise.

Dr. SPECTOR. That is right.

Mr. RAMEY. That assumes that the ground rules are correct. I think there is a good deal of doubt about these ground rules from some analyses that have been made to date.

Representative HOLIFIELD. You find a number of scientists who feel that there are prospects in other areas of development which justify some work along those particular lines of development. They are pretty reputable people.

Dr. SPECTOR. Of course they are. I am sure there can be strong cases developed for differences. I don't view the mission of the Commission as developing all possible routes to economic power and proving them 1, 2, 3, in the next 10 years. Nobody can do that. Therefore, I think if with their present start they can with only the better present prospects accomplish this program, this will be a tremendous achievement. If they attempt to carry along on their back every possible new idea and interject it into the program every time some bright scientist says here is something that looks very good, we are going to slide back to where we have been. I am rather pleased with where we are beginning to be, myself.

Mr. RAMEY. Taking your heavy-water, natural uranium again as an example. This is not a bright new concept. This is the kind of reactor that has been proven at Savannah River for many years. It is a concept that has been with us and people have always worried about the economics on natural uranium. I think you are right in saying if you hold off until 1966 to build a natural uranium prototype, that is pretty far down the scale. If you built one in 1963, or somewhere in there and did not necessarily rely on the Canadians to do all the work for you, it might be possible to find out whether or not it is something for this country.

Dr. SPECTOR. Of course, if they move that schedule up then my criticism with respect to getting outside the boundary of the program would be eliminated. I don't think I can sit here and either defend or challenge the accuracy of the numbers that the Commission has stated. I have simply derived some assumptions if these numbers are correct.

Representative HOSMER. You have used these things more or less as examples of what could go under your principle that we should take our most promising and advanced concept and go ahead fast with them.

Dr. SPECTOR. Exactly.

Representative HOLIFIELD. How do you propose to do this? I notice you said more aggressively by industry contracts, rather than expanding AEC facilities. As I understand it, any of these programs that industry wants to take can be taken on their own. It is only when the AEC finds that industry declines to run with the ball that they pick up the ball and run with it. What are you proposing? Are you proposing that notwithstanding the fact that industry will not operate on its own and finance its own experimental prototypes, notwithstanding that, the Government should go out and contract with them to build for them? As a matter of fact, they do contract with private industry to build them on the AEC properties. So they do it by contract on the AEC properties. What are you getting at there?

Dr. SPECTOR. Certainly, I want to make it clear when it comes as far as the prototype I don't think we can give the responsibility to the Commission and then tell them from day to day how to operate. If the Commission is willing to define the task as research and development, prototype, and so forth, to prove their point, then I think they ought to build a prototype or have it built as soon as they think they can live with it and they should not have to wait to negotiate over a long period of time to the point where some industry might or might not be willing to have a share in that prototype. If there is not somebody ready to move along with it, the AEC should. But then in designing and building that prototype I would like to see this done by contract to the maximum possible amount by industry.

Representative HOLIFIELD. It is done by contract. Every plant that I know of, Hanford, Oak Ridge, and all, have been done by contract. The AEC does it by contract. They call in Babcock & Wilcox, or GE, or somebody to build these plants. They don't build them with Government civil service help, or that sort of thing.

Dr. SPECTOR. This is the point we are making, and we think that it ought to be accelerated and the laboratories and national sites not grow larger, but that the jobs be given to industry as they have been in the past in some cases, so that the capability resides more and more in industry so they will be able to come forward on their own in later cases.

Representative HOLIFIELD. I don't get your point. All of the capability does reside in industry. There is no capability that lies in the AEC to build a reactor that I know of. All of it is done by contract. I don't quite get your point. Maybe I just don't see what you are hitting at. You give an alternative; you said by industry contract rather than in expanding AEC facilities.

Let us take this gas-cooled plant that is going to be built at Oak Ridge. For years we have been trying to get industry to build something like that. They have not built it. Now the AEC is going to go ahead and build it, and they are building it by contract. It does expand the AEC facility at Oak Ridge. It will be a laboratory type of reactor. It will not be an on-line producer like Dresden and and Commonwealth. It will be subject to changes, improvements, interruptions of operations, and uneconomic operation, and all these sorts of things which can be done as well in a laboratory type of reactor which cannot be done in a reactor which is owned by Dresden and Commonwealth, because one of their factors will be the production of kilowatts from an economic standpoint, that is, from the standpoint of getting some return on their investment. So I just don't quite understand what you are striking at.

Dr. SPECTOR. The problem has come in for a fair amount of discussion in the last several weeks. I think our position is closely associated with that which the chamber of commerce took, along with the Manufacturing Chemists Association, and which was answered in some detail by the AEC. I have always felt that not very much is gained by an exchange of "it is, it ain't" arguments. We put to them an example where a contract was let one way and we had hoped it would be let another way, and the Commission comes back and attempts to point out that there was a good reason for doing it that way. I think what we are saying is that generally we would like to

see that policy stated, firmly, clearly, passed on down to the levels that have to execute that policy, and then I think we are all going to be happy.

Representative HOLIFIELD. We want everybody to be happy.

Chairman ANDERSON. What had me a little worried about it was this. Here was Los Alamos working on the plasma thermocouple, so General Dynamics hires Dr. Pidd and brings him to California, and says, "You folks stay out of it; we have the facilities set up to do this work." It is a peculiar feeling.

Representative HOLIFIELD. It is called pirating in industry where you take away a firm's expert at a higher salary, which is exactly what happened in the case the chairman alludes to, and then attempt to exclude work which has already been started or superimpose work on experimental work which has already been developed, like they are doing in this new reactor that is being built by General Dynamics. It is being done on the basis of experimental work that has already been conducted in Government laboratories. They have taken some of the prize scientists, particularly the English, and are building on a foundation already started by a Government laboratory.

Dr. SPECTOR. I don't know much about it, so I cannot comment on it. But I can see I should have been here yesterday. May I continue?

Chairman ANDERSON. Yes, sir.

Dr. SPECTOR. Our company is involved in the production of uranium concentrates, and I would like to comment that since the original announcement of reductions in procurement made on November 24, 1958, we have been unable to make plans for continued uranium production operations, and have been forced to seek guidance from general press announcements rather than clear statements of procurement policy. I interrupt right now to say that I just had a chance to see Chairman McCone's comments in this regard as he presented them to you earlier in the week.

Chairman ANDERSON. I think the committee has been right with you in trying to say this thing should be done by general announcements and not by press statements, and so forth, and I believe the Commission is following that pattern clearly at the present time, is it not? Don't you think this recent statement of how they intend to operate with reference to Canada has helped clear the atmosphere?

Dr. SPECTOR. It certainly has. We agree completely. This is, perhaps, why we are a little bit jealous.

Representative HOSMER. You apparently want some guidelines for the period beyond 1962–63 in this particular product, but I don't think you could get it similarly in connection with other products on the market, do you?

Dr. SPECTOR. I am not sure I understand the question.

Representative HOSMER. You are complaining that you don't know what is going to happen after 1962–63 with respect to the Commission's uranium purchases. I don't know what else Vitro sells, but, if they sell any product to private companies, I doubt if they have any idea beyond 1060 even what the private companies are going to buy. I don't see there is such cause for complaint.

Dr. SPECTOR. I think that statement, standing alone, makes a certain amount of sense. But, basically, we have only one customer for our uranium product. I don't pretend for one moment that our posi-

tion is different from perhaps 12 or 13 other millers on the plateau, who have mills, are running them under current accepted rates, and are wondering whether they are going to run them after 1962 or not. I don't think the problem is complicated. It is a simple problem. We would like to have an answer and have it as soon as we can. We are not surrounding this with any pretense or any generality.

Representative HOSMER. I don't blame you for wanting the answer as soon as you can.

Dr. SPECTOR. I would like to comment, also, as I did last year, with respect to some of the special nuclear materials. I am afraid that Mr. Hosmer is going to ask me the same question all over again.

Chairman ANDERSON. That is one thing about Mr. Hosmer. He believes in what he believes.

Representative HOLIFIELD. I just remark that the Ford Motor Co. would like to know how many motorcars the public is going to ask from them in 1963, too.

Dr. SPECTOR. We are hoping for some improvement here, and perhaps my comments this year have somewhat of a brighter tone because they are tied to what I think has been an excellent example of planning on the part of the Commission, and, frankly, what we are trying to say in certain specific examples is, let use have some more of it because it is going to help us. If I can save some time and leave for the record any comments on special nuclear materials, I will continue.

Chairman ANDERSON. Very well.

SPECIAL NUCLEAR MATERIALS

Dr. SPECTOR. The development of advanced reactor concepts has in the past produced requirements for special nuclear materials from the rare earth series. We feel that additional requirements of special nuclear materials will develop as AEC proceed with their new programs. With reactor programs apparently being planned with greater definition than ever before, we would hope that it would now be possible to give more attention to the definition of requirements for such special materials and that procurement policies be put on a continuing basis instead of the spot-purchase program previously employed. I would like once again to call the attention of this committee to the relationship between the availability of these important materials of the rare earth group and thorium supply. By processing monazite for the production of thorium, substantial amounts of these rare earths are produced as byproducts—which of course must be further refined to meet AEC specifications. Accordingly, we urge the clarification of thorium and rare earth requirements coupled with a procurement policy designed to encourage the development of this domestic industry on an integrated basis.

EURATOM

I would like to make one special word about Euratom. I realize I have jumped all over this program, but it is because of the capability of our company to operate in various fields of this new industry. We do operate internationally, and we have followed the Euratom program, and I want to make a few comments here for what help they might be.

Almost a year ago we suspended our efforts to participate in the Euratom program after a series of meetings with major industry groups. The reasons which have been frequently cited as factors in the failure of this program to fulfill its original objectives—the new fossil-fuel discoveries, decrease in growth rate of energy and fuel requirements, et cetera—have been presented before. However, in addition, we were inclined to doubt that the program would proceed as planned because there was a growing feeling among European industry that they would not learn enough to justify the acceptance of major U.S. participation in many projects in an area where generally there existed a sophisticated industry, although at the moment perhaps not competitive, in this particular area of technology. Therefore, it is our belief that anything less than a clear, almost desperate need for nuclear power was bound to produce major reservations about proceeding with the Euratom program.

However, we believe there is interest in improved reactor concepts and a willingness to justify reactor power economics by new learning opportunities. These motivations can possibly encourage additional Euratom projects to be undertaken under the deferred portion of the program presently requiring completion by 1965. On this basis we would recommend that the program be continued to encourage the development of these possibilities.

Perhaps these comments on Euratom will be viewed as simply hindsight—which has been called the only true science. However, we feel strongly that the disappointments of this experiment should not discourage us from seeking an appropriate instrument to assist the growth of nuclear power in the underdeveloped areas of the world. We know the McKinney panel has been asked to consider this matter and to make recommendations for a program of assistance in such areas and look forward to the results of their study. We feel it will be an important contribution.

Chairman ANDERSON. Thank you, Dr. Spector. The committee thanks you for your statement.

Dr. SPECTOR. Thank you.

Chairman ANDERSON. Mr. Ryan.

STATEMENT OF JOHN J. RYAN, REPUBLIC AVIATION CORP.

Mr. RYAN. Good morning, Mr. Chairman. My name is John J. Ryan. I am vice president of Republic Aviation Corp. in Farmingdale, N.Y. Republic has been engaged as a contractor with the Government for over 25 years. At the present time we are supplying the Air Force with the F–105 fighter-bomber.

I appreciate your invitation to appear before the committee today and participate in your hearings concerning the activities of the Atomic Energy Commission and the various problems relating to the development, use, and control of atomic energy.

A year ago our president, Mr. Peale, advised this committee by letter that:

> It is my hope that the committee's work will furnish the guidance necessary to enlarge the activities of private industry in the atomic energy field and support the Government in its efforts to assume responsibility for vigorous leadership and administration of the nuclear program.

My testimony this morning will relate to the same subject. We are interested in the Commission's program for industrial participation in the test reactor field. We have been active in this program since the Commission's policy was announced in 1956. In association with other companies, Republic has made proposals to invest funds in high-flux test reactor facilities and to furnish irradiation services to the Commission and industry.

Based upon our investigations and studies, we are satisfied that the need for high-flux irradiation services by both the Commission and industry is sufficient to encourage private investment in such facilities. This view is supported by the fact that the Commission received 11 proposals in response to its invitation issued over a year ago. Many more organizations participated in submitting these proposals. In our proposal it was agreed to invest approximately $24 million in such facilities.

In its attempt to change the test reactor program from Government to private ownership, the Commission encountered difficulties in formulating its long-term requirements. These difficulties subsequently led to delays in evaluating the merits of the respective proposals. We have been informed that the Commission is engaged in an intensive reevaluation of projected Commission requirements and in a review of advanced conceptual design studies.

We are supporting the Commission in the revision of its program. In a letter to Mr. McCone dated October 1, 1959, Mr. Peale expressed our interest in furnishing reactor irradiation services in a high-flux test reactor designed to meet the needs of the Commission. Mr. Peale advised the Commission:

> We have indicated our willingness to participate in such a program on the basis of either an industry financed and operated reactor or a Government-financed and industry-operated reactor which will furnish neutron fluxes higher than those currently available. We are prepared to construct a high-flux test reactor of advanced design and to operate the facility in any area in which the public interest will best be served. In addition, we are interested in leasing part of the space in this new high-flux reactor on a cost-sharing basis.

The full text of Mr. Peale's letter and the Commission's reply are appended to my statement for inclusion in the record.

In addition, we furnished for the Commission's review a technical report on an advanced test reactor designed to meet the Commission's highest thermal-flux requirements.

I wish to emphasize to the committee the importance of continuing the Commission's policy of encouraging industry to construct and operate the test reactors necessary to meet the needs of Commission and industry programs. We feel the Commission should adhere to its policy to use Government funds for the construction of test reactors only if its needs for irradiation space cannot be met by private industry under contract with the Commission. These policies are in agreement with the general policy relating to Government procurement from commercial sources. This policy (recently restated in Budget Bureau Bull. 60–2) says that—

> * * * the Federal Government will not start or carry on any commercial industrial activity to provide a service or product for its own use if such product or service can be procured from private enterprise through ordinary business channels.

We recognize that the Joint Committee has advanced the Commission's program for industry participation in the test reactor field. I have in mind, particularly, the legislation of 1958 authorizing the Commission to negotiate long-term contracts with industry for test reactor services. From our experience I feel certain that industry participation in the test reactor program will enhance the growth and development of the atomic industry.

Thank you, gentlemen.

Chairman ANDERSON. I want to thank you for supplementing your statement with the necessary exhibits and material to make us acquainted with this proposal. It is a courtesy that we appreciate.

Mr. RYAN. Thank you.

(The information referred to follows:)

DOCUMENTS RELATIVE TO THE TEST REACTOR PROGRAM

A. "AEC Test Reactor Policy Announced." Press release No. 924, November 8, 1956.
B. "AEC Invites Proposals for Test Irradiation Services." Press release No. TI–11 (A–254), October 2, 1958.
C. AEC's "Abridged Minutes of Information Meeting on Proposals for Irradiation Services, November 19, 1958" (extract).
D. AEC announcement of proposals for test irradiation services. Press release No. B 121, July 24, 1959.
E. Budget Bureau Bulletin No. 60–2, September 21, 1959 (extract).
F. Letter, Mr. Peale to Chairman McCone, October 1, 1959.
G. Letter, Dr. Pittman to Mr. Peale, October 15, 1959.

U.S. ATOMIC ENERGY COMMISSION

Washington, D.C.

No. 924 NOVEMBER 8, 1956.

AEC TEST REACTOR POLICY ANNOUNCED

The Atomic Energy Commission is looking to private industry for the construction and operation of general-purpose test reactors to meet growing needs of the Commission in its reactor development program and those of private industry in the development and construction of nuclear powerplants.

To encourage private enterprise to enter this phase of the atomic energy industry, the Commission will construct test reactors only if its needs for irradiation space cannot be met by private industry under contracts reserving for Government use a percentage of the space available in privately owned test reactors. In addition, the Commission will permit the use of Commission-owned test reactors for nongovernment purposes only if privately owned facilities are not available for the irradiation services required.

Reactors which come within this policy of the Commission include facilities in which materials and reactor components may be subjected to an environment (temperature, radiation intensity, exposure to corrosive materials, etc.) comparable or identical to conditions which would obtain in reactors in which it is intended to use the materials and components; and facilities used to study the effects of radiation on electronic and other components of military vehicles or weapons systems.

The Commission believes that a large part of its requirements for test reactor facilities can be met with privately owned reactors based on proved designs and technology.

In keeping with its new policy, the Commission will, at a later date, invite proposals by private industrial concerns to supply irradiation services suited to the Commission's needs.

Until private industry is ready to finance the design, development, construction, and operation of test reactors of advanced design, the Commission's

policy envisages a continuing Government role in this field and in the development of research reactors of new and improved design which are needed by the national laboratories to carry forward research work assigned to the laboratories. Research reactors provide only limited amounts of space for testing purposes.

The new test reactor policy is another in a series of steps taken by the Commission to bring commercial suppliers into the atomic energy industry. Fuel elements for the materials testing reactor at the National Reactor Testing Station in Idaho, reactor-grade zirconium, hafnium, and beryllium are being procured from commercial suppliers through long term contracts. The Commission has also invited private industry to undertake chemical processing of irradiated fuel elements and processing of enriched uranium scrap from fuel element fabrication, feed materials, and magnesium fluoride scrap. Private industry has recently undertaken the manufacture of boral, a lightweight material for use in reactor and accelerator shielding, which previously had been produced only at a Commission installation.

U.S. ATOMIC ENERGY COMMISSION

Washington, D.C.

No. TI–11 (A–254)

OCTOBER 2, 1958.

AEC INVITES PROPOSALS FOR TEST IRRADIATION SERVICES

The Atomic Energy Commission has invited industry and research and educational institutions to submit proposals for performance of test irradiation services for the Commission. The irradiation services would be performed in reactors specifically designed for testing purposes so that reactor materials and components can be subjected to an environment comparable to conditions in reactors for which the materials and components are intended.

These irradiation services would be used in connection with the Commission's reactor development program which includes projects for both peaceful and military purposes. A portion of these services would be used in connection with the development of fuel elements which are expected to lower the cost of nuclear power.

The Commission believes that a large part of its requirements for test reactor facilities can be met with non-Government-owned reactors which are based on proven designs and technology. The invitation furthers a Commission policy announced in November 1956, of fostering the construction of test reactors by industry. At that time, to encourage commercial participation in this phase of the atomic energy industry, the Commission announced that it would construct additional test reactors only if its needs for irradiation space could not be met by other sources. The Commission also had announced that it would permit the use of Commission-owned test reactors for non-Government purposes only if other facilities were not available for the irradiation services required.

Requirements of industry and other Government agencies for space in test reactors are expected to increase significantly over the next several years. To assure the availability of testing space and thus reduce the demands on the Commission for such space, the Commission will give consideration to the extent to which proposers will make irradiation space available to non-Commission users.

The irradiation services for the testing program now planned will be needed over at least a 5-year period. The required services are in addition to those available in the materials testing reactor and the engineering test reactor now operating at the Commission's National Reactor Testing Station in Idaho.

Details of the invitation for proposals may be obtained from the Director, Division of Reactor Development, U.S. Atomic Energy Commission, Washington 25, D.C. Deadline for submission of proposals is January 12, 1959.

52950—60——17

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., December 24, 1958.

DEAR SIR: A copy of the abridged minutes of the November 19, 1958, information meeting concerning proposals for irradiation is enclosed.

Your attention is invited to the fact that our "Request for Proposal To Supply Irradiation Services" has been revised as set forth under section B of the abridged minutes.

Proposals to furnish irradiation services should be submitted no later than January 12, 1959, as instructed in the "Request for Proposals To Supply Irradiation Services" which was made available at the meeting.

Sincerely yours,

W. M. BABB
(For Frank K. Pittman, Director,
Division of Reactor Development).

Enclosure:
Minutes of meeting, November 19, 1958.

ABRIDGED MINUTES OF INFORMATION MEETING ON PROPOSALS FOR IRRADIATION SERVICES, NOVEMBER 19, 1958

The following information represents a summation and clarification of questions raised and answered at the information meeting held in Germantown on November 19, 1958. Incorporated also are those changes to the revised request for proposals now deemed appropriate. In addition, those questions raised by letter prior to the meeting, and which were not answered at the meeting, have been included and answered herein. Questions and answers have been roughly grouped according to the major divisions of our request.

A. SERVICES REQUIRED

Question. Is AEC interested in constructing additional test reactors with its own funds?

Answer. AEC policy remains the same today as announced 2 years ago. The AEC will not construct general-purpose test reactors if services required can be obtained from privately owned and operated test reactors. Only if AEC requirements for irradiation services can not be met by private industry would AEC consider constructing additional Government-owned test reactors.

Question. Are your requirements in excess of the capacity of MTR–ETR? In excess of these and the NRU?

Answer. Yes.

B. SPECIFICATIONS

Under Section B—Specifications, delete second paragraph and substitute therefor the following:

"The AEC is not seeking a proposal to build a single reactor or reactor complex which would satisfy all of the listed requirements. It would prefer that there be three or more reactors in which AEC would be a major but not the sole user. The extent and nature of the response to this invitation will be important in determining the number of contracts to be negotiated."

Question. Will all of the loops be of the through type or may some of them be reentrant or hairpin type?

Answer. In general, if the loop meets the functional requirements and other specifications of appendixes A and B, the type of loop is of secondary importance. The advantage of a through loop is that it generally affords the maximum useful test volume for a given size hole in the test reactor. In appendix C, we have specified a number of holes in different size and flux ranges. In order that these holes may have maximum potential advantage, some of them should be capable of accommodating through loops.

(This is p. 1 of a 10-page document.)

U.S. ATOMIC ENERGY COMMISSION

Washington, D.C.

No. B.121

JULY 24, 1959.

AEC SELECTS, AS BASIS FOR CONTRACT NEGOTIATIONS, PROPOSAL OF BABCOCK & WILCOX CO. FOR TEST IRRADIATION SERVICES

The Atomic Energy Commission has selected, as a basis for contract negotiations, the proposal of the Babcock & Wilcox Co. to provide the Commission with test irradiation services in a 60,000-thermal-kilowatt test reactor the company would build in Lynchburg, Va.

The proposed test reactor would be water cooled and moderated. It would take 2 years to build and would be used to provide irradiation services for a 5-year period. The estimated cost to the Commission would be about $15 million over the contract period. The reactor will be used primarily to meet the Commission's test needs for neutrons in the low- and mid-flux ranges.

Neutron flux is the intensity of neutrons in a given area of a reactor to which components and materials may be subjected. This area provides environmental conditions similar to conditions in reactors for which the components and materials are intended.

The Babcock & Wilcox proposal was selected from among 11 submitted in response to a Commission invitation issued last October. Two proposals later were withdrawn.

To meet the Commission's expected low- and mid-flux requirements for irradiation services during the 2-year period of construction of the reactor at Lynchburg, as well as other requirements for irradiation services which may not be assigned to the Babcock & Wilcox reactor, the Commission will negotiate for space in other privately owned test reactors which are existing or may be built.

None of the proposals provided an acceptable means of meeting a substantial portion of the Commission's high-flux test requirements included in the public invitation. The Commission, therefore, is initiating a design study of an advanced test reactor to meet these needs, and will discuss with industry and other interested parties the extent to which such requirements may be met in privately owned reactors.

EXECUTIVE OFFICE OF THE PRESIDENT

BUREAU OF THE BUDGET

Washington, D.C.

BULLETIN No. 60-2

SEPTEMBER 21, 1959.

To: The heads of executive departments and establishments.

Subject: Commercial-industrial activities of the Government providing products or services for governmental use.

1. *Purpose.*—The purpose of this bulletin is (*a*) to clarify the application of existing policy regarding competition between the Government and private enterprise in the light of executive branch experience under Bureau of the Budget Bulletins No. 55-4 of January 15, 1955, and No. 57-7 of February 5, 1957, and (*b*) to provide for the evaluation of all commercial-type enterprises not previously reviewed. To make this program more manageable, procedures have been designed to simplify reporting and to permit agencies to direct their major attention to those activities of greatest significance and budgetary impact.

2. *Policy.*—It is the general policy of the administration that the Federal Government will not start or carry on any commercial-industrial activity to provide a service or product for its own use if such product or service can be procured from private enterprise through ordinary business channels.

REPUBLIC AVIATION CORP.,
Farmingdale, N.Y., October 1, 1959.

Hon. JOHN A. MCCONE,
Chairman, Atomic Energy Commission,
Washington, D.C.

DEAR JOHN: We have noted the Commission's desire to discuss with industry the extent to which the high-flux test requirements of the Commission may be met in privately owned reactors. The Commission's views on this subject appeared in its news release dated July 24, 1959, and were restated to representatives of our industry group in a meeting with the Commission's staff members at Germantown on July 29, 1959.

We wish to bring to the Commission's attention our continued interest in furnishing reactor irradiation services in a high-flux test reactor designed to meet the needs of the Commission.

We have indicated our willingness to participate in such a program on the basis of either an industry financed and operated reactor or a Government-financed and industry-operated reactor which will furnish neutron fluxes higher than those currently available. We are prepared to construct a high-flux test reactor of advanced design and to operate the facility in any area in which the public interest will best be served. In addition, we are interested in leasing part of the space in this new high-flux reactor on a cost-sharing basis.

Three basic plans for industry and the Commission to collaborate in providing a new high-flux test reactor of advanced design are summarized in the following table:

Plan	Design	Site	Construction	Operation
A	Industry	Industry	Industry	Industry.
B	AEC	do	do	Do.
C	do	AEC	AEC	Do.

Under plan A, the industry group proposes to design, build, and operate a high-flux reactor with private funds on its own site. Under plan B, the industry group proposes to finance, build, and operate a reactor designed by the Commission on an industry site. Both plan A and B are guided by AEC policy to foster private participation in the test reactor program as described in its policy statement of November 8, 1956, and restated in the minutes of its irradiation services information meeting held on November 19, 1958.

Should circumstances make it desirable that the reactor be Government owned but operated by private industry on a contractual basis, then the industry group emphasizes its interest in being selected as the industrial operating contractor. Under plan C, therefore, the industry group proposes to participate in the design of a facility constructed under direct authority of the Commission and to operate the facility under contract with the Commission.

The companies making up our industry group have diverse business activities but have a common interest in developing nuclear energy from different points of view. Allis-Chalmers is actively engaged in the nuclear power program; Minnesota Mining & Manufacturing Co. is engaged in research and development of new materials for the nuclear industry; Republic Aviation has a vital interest in nuclear propulsion and nuclear energy for space applications.

The nuclear activities of these three companies include such aspects of nuclear development as research, test, and power reactor design, development and construction; reactor fuel elements, high temperature materials, thermoelectric materials; plasma propulsion systems; design studies for nuclear-powered vehicles; and radioisotope applications. As a consequence of these interests and activities, the group has acquired an extensive nuclear capability.

We have prepared a conceptual design of an advanced test reactor which meets the Commission's highest thermal-flux requirements, including those of the naval program. The design of the reactor facility will allow for future modification to achieve higher fluxes, if required. Other features of the proposed design include long regions of usable test space and improved mechanical arrangements. A copy of the design study is enclosed with this letter.

We will appreciate your consideration of this proposal, and the opportunity to discuss the details of the conceptual design study with the Commission at its convenience.

Very truly yours,

MUNDY I. PEALE.

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., October 15, 1959.

Mr. MUNDY I. PEALE,
President, Republic Aviation Corp., Farmingdale, N.Y.

DEAR MR. PEALE: Your letter of October 1, 1959, to Mr. McCone has been referred to me for reply.

We are most appreciative of the interest shown by the Republic Aviation, Allis-Chalmers, and Minnesota Mining & Manufacturing group in furnishing reactor irradiation services in a high-flux test reactor designed to meet the needs of the Commission.

It is still our intent to discuss with industry how these needs may be met in privately owned reactors. In preparation for the discussions, we are presently undertaking an intensive review and reevaluation of projected Commission requirements, as well as a review of the conceptual design study prepared under direction of the AEC Idaho Operations Office. The Republic Aviation Corp. report on conceptual design studies, which was enclosed with your letter, is also being reviewed in connection with the undertakings described above.

We shall notify you promptly when we have completed this work in order to establish mutually satisfactory arrangements for a meeting with representatives of your group.

Sincerely yours,

FRANK K. PITTMAN,
Director, Division of Reactor Development.

(Original signed by A. J. Vander Weyden.)

Representative HOLIFIELD. I would like to ask you if you are aware of the record of privately built test reactors in obtaining customers? I recently visited an installation on the west coast where a private company had built quite a number of hot cells, and their complaint was that industry was not using them. We have run across the problem of competitors using another competitor's test reactor right along. Have you any solution for that factor? We did go along with some of these test reactors being built by private industry, and I think their experience has been that their competitors don't want to use them.

Mr. RYAN. To answer your question, sir, I am not fully familiar with it. I am familiar with part of it. I am familiar with the last observation you made, that the competitive position in the industry does create a problem as to Mr. Jones using Mr. Smith's reactor. However, the conclusion that I have drawn is based on a market survey which we caused to be made a few years ago by a reputable industrial engineering firm, plus a survey we made of our own whereby we felt that there was a need for a high-flux test reactor and that we could generate customers for it.

Representative HOLIFIELD. I would say that you undoubtedly have a survey to fall back on, but we have actual experience to fall back on in other types of scientific services offered by competitors to competitors, and we just find that there is a natural reluctance. I am not criticizing it because, certainly, the operator of a test reactor of any type, whether it is high flux or low flux, knows what happens in that cell. He has to follow the instrumentation with his experts to make a report to the individual renting a cell. If it does happen to be in

the field of trade secrets, as we ordinarily call them, then it is no longer a trade secret by the man who hires the hot cell in a test facility. It becomes a joint piece of knowledge between the renter of the cell and the owner of the cell. This, it seems to me, is a pretty insurmountable factor to overcome. If you have a test reactor—I can't recall now, but it seems to me that there is a service that is offered on a completely objective basis by a firm that is not a competitor. It seems to me it is Battelle Institute. I could not think of the name right at the moment. That type of operation would be, it seems to me, an operation where every competitor could go and be entitled to an objective secret analysis of his test. But where you have the competitor himself owning the test reactor and another competitor forced to come to him, I just don't think you will overcome that type of objection.

Representative HOSMER. If the gentleman will yield, is Republic engaged in any other type of atomic work in this proposed running of a test reactor business?

Mr. RYAN. Not at the moment we are not; no.

Representative HOSMER. Then if you stayed pure and clean of other work, you would not run into the situation Mr. Holifield mentioned. But the minute you start to expand in any other type of atomic business, you would put yourself in competition with your customers on your test reactor. At least there would be a suspicion that conflict might arise.

Mr. RYAN. Yes. I admit the problem is there.

Representative HOSMER. There is one other thing I want to nail down right now. Anybody who goes into this business had better go into it on the same basis of confidence with their customers as attorneys have with their clients. Otherwise, they are not going to get a business going at all. I think that is the basis of Mr. Holifield's suggestion, that at the present time these people want to go to Government laboratories because they know their information will be protected. But they are not sure it will be protected if they go into the laboratory of a competitor.

Mr. RYAN. That is right. The proprietary interest is a problem.

Representative HOLIFIELD. An operation like Battelle or any university-operated project or something like that, operated by an objective entity, would solve the problem. I con hardly see where in this particular field you can mix up the private enterprise operation with competitive operations. There may be a solution, but I don't see it.

Mr. RYAN. I don't have one at the moment, I assure you.

Chairman ANDERSON. Thank you, Mr. Ryan, very much.

Mr. RYAN. Thank you.

(Subsequently the following letter regarding Mr. Ryan's testimony was received and is incorporated in the record:)

REPUBLIC AVIATION CORP.,
Farmingdale, Long Island, N.Y., March 8, 1960.

Senator CLINTON P. ANDERSON,
U.S. Senate, Washington, D.C.

DEAR SENATOR ANDERSON: At the time I testified before the Joint Committee on February 19 of this year several members of the committee raised the question of a potential conflict of interest existing between the operator of a privately owned test reactor and the customers using the reactor facilities for the conduct of their own experiments. The discussion which ensued provoked a number of interesting comments, and I thought you and the members of the committee would be interested in the views we have adopted on this subject and

which we have attempted to outline briefly for your consideration in the remainder of this letter.

We believe the problem is a real one which necessarily exists in varying degrees in connection with the operation of any facility offering services to competing customers. It is also our view that a satisfactory solution to the problem is essential in order to generate sufficient commercial use of the reactor to insure a successful enterprise. In our opinion, however, adequate methods for safeguarding proprietary interests are presently available and should be offered to each customer utilizing the services of the facility. Some of the proposed methods and programs we are willing to adopt in the operation of a high-flux test reactor are the following:

First: The reactor operator will be organized with a separate and distinct corporate identity with suitable provisions contained in its charter to restrict it from adopting interests which may conflict with its primary function of operating the facilities for the Government and commercial users.

Second: The operator will offer its customers a contractual guarantee to safeguard all confidential disclosures required of the customer to provide for the safety and control of the reactor during the experiment.

Third: The contractor will allow each customer to maintain control of the data relating to its own experiment by permitting the use of the customer's personnel to record, analyze, and interpret the results of the experiment.

Fourth: The operator will offer its customers a contractual guarantee not to publish, use, or disclose information communicated by the customer or developed from the customers' experiment for its own benefit or for the benefit of other customers.

Fifth: The operator will not seek or impose against customers an obligation to waive any of their proprietary interests or rights disclosed or developed in connection with their experiment in order to utilize the services of the reactor.

We are convinced the adoption of the program sketched in this letter will not only eliminate concern by the users of the test reactor regarding the safety and confidence with which their information will be treated by the reactor operator, but also will permit private industry to carry on proprietary irradiation testing work with greater freedom from the restrictions imposed on proprietary work in Government-owned and industry-operated testing facilities.

Very truly yours,

JOHN J. RYAN.

Chairman ANDERSON. The last witness is Mr. Gordon Weller, of the Uranium Institute of America.

STATEMENT OF GORDON A. WELLER, URANIUM INSTITUTE OF AMERICA

Mr. WELLER. Thank you, Mr. Chairman and members of the Joint Committee on Atomic Energy, my name is Gordon Weller. I am executive vice president of the Uranium Institute of America. Our corporate charter on file here in the District of Columbia directs that we shall engage in activities that will improve the cooperation between Federal and State Governments and all segments of the nuclear fuels industry; to foster and encourage the science of finding, producing, processing, fabricating, and marketing uranium; and to engage in any lawful activity that will improve the economic progress of the industry. Our institute headquarters is at Grand Junction, Colo.

Before getting into the main testimony, I should like to answer one question that was presented to Dr. Spector. The Atomic Energy Commission provided a projection of uranium commitments and deliveries to the industry last April 1959, which provided a rather clear-cut prospectus for the industry. I think this might be an adequate answer to Mr. Holifield in his question about the Ford Motor Co. planning its future production.

Representative HOLIFIELD. Does that represent both domestic and international, or just domestic?

Mr. WELLER. It includes projections as of April 1959 for domestic, Canada, and overseas.

Representative HOSMER. How many years?

Mr. WELLER. Through 1966; calendar year 1966.

Representative HOLIFIELD. Then your point is that information is available to Dr. Spector?

Mr. WELLER. We have been provided assurances that this market would exist; yes, sir.

Representative HOLIFIELD. I did not understand exactly what Dr. Spector meant. Maybe he was speaking in terms of not the whole industry but his specific plant. He did not know how much of that projected purchase he would get. Maybe that was the point.

Mr. WELLER. I see. Of course, it would not be proper for me to speak on behalf of his specific operation.

This is the fourth year that we have had the honor of being invited to submit testimony at these hearings, and we wish to assure you of the Uranium Institute's desire to cooperate fully with the informational needs of this committee and other committees of the Congress.

URANIUM VIEW, 1960

The year 1960 is significant for the uranium industry. This is the year we achieve the full rate of production which has been set for us by the Atomic Energy Commission. During this year, for the first time, the domestic industry will produce more uranium concentrate for purchase by the Atomic Energy Commission than that purchased from Canadian and oversea sources. In the years immediately ahead, we will see the quantity of uranium to be purchased from nondomestic sources continually reduced, while the domestic industry's production remains at its present level of approximately 18,000 tons per year through the calendar year 1966.

Without a doubt, the United States has outdone every other nation in the world in its procurement of uranium. We have justified this program on the basis of the tremendous potential energy which can be produced from this miracle fuel for both the military and the peaceful requirements of our Nation.

Those of us in the industry have been proud of our part in the accomplishment of these objectives because of our strong conviction that the farsighted plan to develop this important reserve of uranium will, in the years immediately ahead, prove to be one of the most important investments that our country has ever made. First, our growing uranium supplies and our rapidly advancing nuclear-power technology will remove all doubts as to our long-range capabilities as a leading industrialized Nation of the world. Secondly, it will justify the development of technology which will best utilize the promising chemical and energy potentialities of other fuels which are abundant in our country. And, third, our supply of uranium assures us of our ability in the years immediately ahead to extend a helping hand to the underdeveloped countries of the world, to help to improve their standards of living, which is so closely tied to power

production, and to thereby broaden the commercial possibilities for all industrialized nations of the world.

We hold to these convictions in spite of the temporary setbacks that various phases of the atomic energy program have experienced in the past 2 years.

STATUS OF THE INDUSTRY

In its annual report to the Congress for the year 1959, the Atomic Energy Commission has provided an excellent review of the present status of the uranium industry (pp. 55–62). We commend your reference to this excellent presentation for many of the facts concerning the present status of the industry. Because of this review, this presentation will avoid many of the matters upon which we might otherwise wish to dwell. We do have a few comments, however, which are inspired by the 1959 AEC annual report.

While the industry has established its production levels at the present time with an annual production of about 18,000 of U_3O_8 per year, and expects to operate at approximately this level through the calendar year 1966, there are a great many uncertainties, the solutions for which we hopefully look to the remaining months of 1960 to bring.

Before describing these uncertainties, however, perhaps I should justify this contention by directing your attention to a symptom of our problem. As you know, a substantial part of this industry's growth was the result of investment capital provided the industry through the issue of public stock and bond subscriptions. In the early years of the uranium industry, uranium stocks were recognized for the speculative quality that they were. At the present time, however, a great deal of the speculation has been removed from the industry, and uranium stocks should compare very favorably with other mining-industry stocks.

Such is not the case, however. I do not appear before this committee as an expert analyst of uranium stock issues, nor is it my desire to influence the market value of uranium stocks through any statement I make here. I do submit, however, as one very positive evidence of the uncertainties of our industry, the very low level at which uranium stocks presently are priced with respect to returns which are indicated through the procurement program of the Atomic Energy Commission and the established reserves which have now been developed with a great degree of conservatism.

In considering this problem with security analysts, I have come to the conclusion that these artificially low prices are almost entirely due to the generally recognized uncertainty by the investing public, which the uranium industry faces in its relationship with the Government.

My principal purpose in appearing before you today, therefore, is to solicit your very valuable assistance in helping to remove some of these areas of uncertainty and to thereby effect the industrial health for the uranium industry that is warranted through the efforts of the Atomic Energy Commission and this committee of the Congress.

Let me give you some examples.

STATUS OF MILL CONTRACTS IN THE URANIUM INDUSTRY

A brief review of the status of contractual relationships of the milling industry with the Atomic Energy Commission in the various States does not produce a wholly reassuring picture. Very briefly, the picture is this:

Oregon has one mill, with the contract due to expire late in 1963. The economics of the uranium operations in Oregon appear to be extremely tight, and prospective operations which were apparent at the time of mill negotiations now appear to be extremely marginal.

Washington, Arizona, and South Dakota each have one uranium mill, with contracts due to expire at the end of March 1962. Independent operators in these States are finding market conditions difficult to meet, and in many cases have ceased operations.

Wyoming, one of the most recent States to come into the family of uranium producers, has one of the most secure outlooks at the present time. Of the five mills now operating in that State, only one is yet to renegotiate its contract to the end of 1966, and this mill now holds a contract through late 1963. Markets for independent production in this State appear to be generally good, but some operators anticipate a breakdown of the allocation system in the post-1962 period.

Mill capacity in New Mexico now constitutes over 50 percent of the industry's production, and three of the mills now hold contracts through 1966. The former contract for the mill at Shiprock expired October 31, 1959, and negotiations proceeded until November 24, before an extension was finally negotiated. Eighty-five percent of the uranium ore tributary to this mill comes from the Navajo Reservation, and a great deal of uncertainty confronted the operators in this area before the mill contract was consummated, almost a month after termination of the earlier agreement.

Most of the contracts for milling operations in both Wyoming and New Mexico are of such short duration as to preclude the possibility of full amortization of capital investment prior to March 1962, the terminal date set for fast writeoff on a 5-year basis. Some of the mills in this category were successful in negotiating contracts through 1966 which served as some compensation that permitted the proper financing of mill construction costs. Other mills are yet to receive contracts for the post-1962 period—a matter which we understand is now well advanced in its negotiation stages of the Commission.

Of the four mills operating in the State of Utah in 1959, the Government-owned facility at Monticello was placed on a standby basis at yearend. This mill afforded an important market to independent ore producers, but also complicated a limited eligible ore reserve situation with respect to the remaining mill capacity. Two of the three remaining mills now hold contracts through 1966, and the third through March of 1962.

Seven mills are operating in Colorado, with the most recently authorized facility at Canon City operating under a contract expiring at the end of calendar year 1965. The Gunnison plant holds a contract to the end of 1962; all other mills hold contracts which terminate in March of 1962, except for the Grand Junction mill, whose contract expires in July of this year.

According to our analysis, then, 11 of the 25 mills now authorized by the Commission hold contracts which expire in March of 1962 or before. Three additional mills will require new contracts in 1963 if they are to continue to operate under the Government market. The Grand Junction contract is now so close to termination that a condition similar to that experienced in the Shiprock contract is now seriously threatened. All mining and auxiliary operations, as well as the companies involved in such contracts, find it extremely difficult to establish production schedules and maintain proper employment morale under such conditions.

We have contacted most of the milling companies holding contracts which expire in 1962, and we are advised that negotiations are weel in progress, with the expectation for successful completions before the end of this year—a condition which will greatly relieve the uncertainties now being experienced.

MODIFIED PURCHASE PROGRAM 1962–66

Markets for uranium in the period after March 31, 1962, and extending through calendar year 1966, will be subject to the modified purchase program announced by the Commission on November 24, 1958. As you know, this modified program limited the market guarantee announced by the Commission on May 24, 1956, for the purchase of uranium.

The earlier purchase program provided for a "guaranteed market for all uranium concentrates produced by domestic mills from domestic ores, subject to a limitation, at the Commission's option, of 500 tons of U_3O_8 per year from any one mining property or mining operation, and to compliance with Commission specifications." [1]

In announcing this first post-1962 market guarantee to the industry, the Commission explained that the action was taken "in recognition of the need for a continuing Government market in order to maintain a high rate of exploration and development." [1] The effect of this program was to provide regions which had sufficient established milling capacity with the assurance that ore reserves could be marketed as and when they were discovered in accordance with the ability of existing operations to process the ores produced. In areas of new establishment where inadequate mill capacity existed, the program provided sufficient assurance to justify extensive drilling programs to define ore reserves and to thereby justify proposals for the construction of new mills and the commitment by the Commission for the purchase of uranium concentrates produced therefrom.

When this first post-1962 program for the purchase of uranium was modified on November 24, 1958, areas with sufficient established milling capacity were caught without any extensive reserve development programs accomplished because such work did not appear to be needed under the original program—no new mills were required. Areas which required new mill capacity, however, utilized the program to establish adequate reserves to justify such mills and therefore were able to qualify their newly established reserves as eligible ore under the modified purchase program.

[1] Press release No. 830, issued by the Atomic Energy Commission, May 24, 1956.

As a result, the November 24, 1958, announcement was seriously punitive to the districts of older establishment—particularly those which are characterized by many scattered small deposits—areas favorable to operation by independents. Districts of this type occur in Colorado and Utah, South Dakota, Arizona, and Washington, and to some extent in New Mexico and Wyoming.

Accordingly, the modified purchase program in general, has been most punitive with regard to the independent producer located in these areas, and has compelled this organization, by virtue of its charter, to argue vigorously for relief of this segment of the industry, although we are not conceived to be an organization which exclusively represents the cause of the independent, nor of any given area.

We cannot overemphasize the seriousness of one aspect of a modified purchase program as it is now being administered by the Atomic Energy Commission. The November 24, 1958, announcement stated that the Commission "will carry out its May 24, 1956, commitment with respect to ore reserves developed prior to this date." The key to the administrative procedures established for the execution of this policy is the definition of what constitutes "ore reserves."

At the time that the Uranium Institute issued its "blessing in disguise" reaction (UIA release No. 54, issued Nov. 25, 1958) to the modified purchase program, we interpreted the term "ore reserves" to refer to presently established uranium districts. It was inconceivable to us then, and it is today, that the Commission could authorize the construction of milling facilities under a policy which offered every assurance in the world that such mills would operate through calendar year 1966, so long as there was ore production available for processing within the terms of the mill contracts involved, and then to adopt a policy which would artificially render ineligible ore reserves which would otherwise be available for such operations.

We need only remind ourselves of the fact that in the oldest uranium district, the Colorado Plateau, mills were authorized and built, in the early period of this program, of sufficient capacity, that they would have consumed the then-known ore reserves in 18 months' time. Yet, this capacity has been operating and growing for more than 10 years. It is obvious that the Commission itself justified its program on ore reserves that were implied rather than actual. Accordingly, the term "ore reserves" has had broad meaning, and was so interpreted when the modified program was announced in November of 1958.

In actual experience, operators have indicated that methods for the appraisal of ore reserves have been changed several times during the course of negotiations, with the Commission, for the establishment of eligible reserves under this program.

We submit that such arbitrary administration of the modified purchase program is in serious violation to the basic concepts under which the industry initiated its operations.

We submit the procurement program should be permitted to proceed through 1966 for the districts which were established as of November 24, 1958, to such extent as mill capacity has been authorized and as ore production from all reserves in those districts will permit.

We further submit that any other interpretation of this program will be so arbitrary in nature as to create inequities resulting in tre-

mendously difficult administrative functions that will require excessive policing and adjudication functions by the staff of the Atomic Energy Commission at Grand Junction and its branch offices.

Still another ominous threat confronts producers in the vanadium-uranium ore districts of the Four Corners region if the present procedures of the Atomic Energy Commission are rigidly pursued. The program will force 90 percent of the independent operators out of business before the conclusion of the procurement program in 1966 because of lack of "eligible reserves." The tragedy of this prospect lies in the fact that in the post-1966 commercial markets for uranium, production from vanadium-uranium ores may prove to be of great appeal because of the byproduct status, which uranium will be permitted to assume with respect to vanadium in such mining districts. Independent operators, therefore, might be able to continue to enjoy a mining occupation which they have followed in many cases for more than 30 years in this region, if they are not forced prematurely to terminate their operations because of arbitrarily drawn administrative procedures.

Mr. Chairman, because of its concern as to the effects of modified purchase program on uranium-producing areas of western Colorado, and because of the then expected exercise by the United States of options for purchase of further quantities of uranium from rondomestic sources, the Gunnison (Colo.) Chamber of Commerce board of directors framed and adopted a resolution concerning the continued domestic uranium markets through the year 1966. This expression became known in the industry as the Gunnison resolution, and was subsequently adopted by many city councils, boards of county commissioners, chambers of commerce, and other organizations concerned with the economic well-being of uranium areas of the West. With your permission, I should like to include for the record a copy of the Gunnison resolution, and the list of organizations which adopted this expression during the late summer and fall of 1959.

(The information referred to follows:)

GUNNISON RESOLUTION CONCERNING THE CONTINUED DOMESTIC URANIUM MARKET THROUGH THE YEAR 1966

Whereas the uranium industry has been developed through the urgent requirements of the U.S. defense program, and the promise of a highly productive "Atoms for Peace" program; and

Whereas the U.S. Atomic Energy Commission on May 24, 1956, issued positive assurance to the domestic uranium industry that a market for uranium concentrates would be assured through the calendar year 1966, with properly defined production limitations; and

Whereas hundreds of uranium operators and mining companies have made substantial investments based upon the assurances that were issued by the AEC, of which the May 24, 1956, announcement cited above is only one example; and

Whereas substantial progress has been made since 1956 in the perfection of nuclear reactors for the production of electric power, and the propulsion of vessels and vehicles through the water and air, and on the land, thereby assuring the continuing and growing market for uranium for peaceful uses; and

Whereas the United States has been buying uranium concentrates from the Dominion of Canada and from other foreign sources for the past 5 years at prices 25 to 40 percent above the average price paid for concentrates to the domestic industry, and the AEC, within the past few months, has extended its commitments to Canada at a time when increasing limitations were being imposed upon the domestic industry; and

Whereas the development of the uranium industry has involved the employment of thousands of skilled and semiskilled people, the investment of millions

of dollars in plant and mine facilities, and the expansion of many western communities to accommodate the housing and trade requirements of the newly developed uranium industry: Now, therefore, be it

Resolved:

1. The Atomic Energy Commission and the U.S. Congress maintain the required markets for uranium through its raw materials procurement program to permit the industry to operate at the level which has now been established in existing and negotiated mill capacities and concentrate production levels, through the calendar year 1966.

2. The Atomic Energy Commission and the U.S. Congress continue to support such research and development programs in the field of the peaceful uses of atomic energy and of uranium as a nuclear fuel, to speed the achievement of economic uses of uranium for the growing energy requirements of this Nation and of the other friendly countries throughout the world.

3. The Atomic Energy Commission and the U.S. Congress authorize no further commitments for the procurement of uranium from sources outside the United States so long as procurement from domestic sources is restricted.

ORGANIZATIONS WHICH HAVE ADOPTED THE GUNNISON RESOLUTION

City Councils:
- Cortez.
- Delta.
- Grand Junction.
- Gunnison.
- Lake City.
- Leadville.
- Naturita.
- Montrose.

County commissions:
- Gunnison.
- Hinsdale.
- Lake.
- Mesa.
- Moffat.
- Rio Blanco.
- San Juan.

Chambers of commerce:
- Glenwood Springs.
- Grand Junction.
- Gunnison.
- Paonia.

Others:
- Club 20 (representing 20 western Colorado counties).
- Grand Junction Junior Chamber of Commerce.
- Uranium Institute of America.

PROBLEMS OF THE INDEPENDENT PRODUCER

Mr. WELLER. We must be mindful of the fact that no procedure has ever been established by the Commission guaranteeing a market for ore production from independent producers except for small quantities of carnotite and roscolite ores, eligible for purchase at the Monticello mill under Circular 5. Markets which presently exist for such producers are by virtue of mill contracts, with provisions for a stipulated percentage of mill capacity to come from independent producers if the ore is available. These mills are at liberty to shift their markets, however, from one producer to another, or to adjust their specifications for minimum grade or amenability of ore, in a fashion best suited to the mill's operating convenience. It is obvious therefore that this practice has not provided the assured market to

independent producers which exist under Circular 5, nor which is enjoyed by the mills for their own ore production.

Some mills are currently operating at custom ore capacities considerably less than that specified in their contracts. No public review is ever made by the Commission of such operations before authority is granted for such contract deviations resulting in a reduction of custom capacity in favor of ore production from the mill's captive mines.

These operating conditions have placed the mills in a very dominant position, wherein they can inflict serious punitive policies on those independents who might question operating policies, challenge ore-sampling procedures, or might support organiaztions which are not endorsed by such mills.

A few years ago, in discussing these matters with Commission officials in Grand Junction, we expressed our fear that this trend was developing. We were advised that when the program was completed, there would be sufficient milling capacity in uranium-producing districts to force the mills to compete for ore production from the various independent producers. We find now, of course, that such competitive spirit between mills is rare. Ore reserve growth long ago outstripped mill development.

Fortunately, most of the mills have recognized the responsibility which has been placed upon them in their present position as ore buyers, and have voluntarily established very equitable buying procedures, intended to maintain the healthiest market environment for the operators tributary to their operations. Several positive steps could be taken, however, to relieve the problems of the independent producers which I have just described to you.

(1) The terms of contracts with every milling operation in the domestic industry and the agreements with all foreign sources for uranium which have been negotiated by the Atomic Energy Commission should be placed on open file. The condition exists today that the independent producer is denied an exact understanding of the nature of the market under which he has made large investments, created many obligations including the employment of many mining and administrative people. We have urged that the Commission adopt this policy of contract terms disclosure for more than 12 months, and have discussed it in private conferences with Commission officials and in open meetings. We emphasized the problem again in testimony before the Joint Economic Committee last October and on the same day were assured by an official of the Commission in the presence of many outstanding authorities in the atomic energy field that mill contracts would be placed on open file in the immediate future.

Mr. Chairman, we find that this policy is yet to be adopted at the Grand Junction Operations Office, and I do not believe it is in practice here in Washington.

(2) Monthly reports should be issued by milling companies to the Commission, and made available for public review of the quantities of ore received room each producer and processed. Furthermore, the names of producers who have shipped ore to mills and have been refused a market should be given, and the reasons for such refusal made evident.

(3) A procedure for adjudicating market hardship and inequities should be established to assure equal treatment among all independent producers tributary to any given market.

It is our belief that if these procedures were adopted by the Commission, there would be rare occasion for producers to have to resort to adjudication procedures in order to maintain an adequate market relationship.

Another facet of the problem of the relationship between mill and independent operator is that it has been frequently necessary for the mill to impose a quota on the production of an operator which has prevented that operator from producing all of the ore from his certified properties for which he would be eligible for production bonus under the modified domestic uranium program, Circular 6 (F.R., title 10, pt. 60, sec. 60.6). Brief reference is made to this provision of the Commission uranium-buying program on page 59 of the annual report.

We strongly urge that the Joint Committee and the Commission reexamine the unfulfilled portion of the bonus program, as it is now shortly to expire on March 31, 1960, and to consider extending bonus payments to those small operators who have had properties certified for bonus payment, but who have been unable to fully utilize the bonus for which they were eligible because of limited markets for their production.

Representative HOLIFIELD. Has there ever been any reason advanced for not making these contracts public as being connected with national security?

Mr. WELLER. No, sir. The reason that they have not been made public, as set forth by the Commission officials, is that they are company confidential and that the Commission feels that it does not have the right to make them public, but the companies are at liberty to do so if they want to. The problem is that the precedent of confidentiality was established by the Commission. Each of these contracts were negotiated in secrecy during the early stages of the procurement program and there would be a natural tendency, I think, for the Commission to want to improve each successive negotiation. I think this is entirely proper. There, of course, was also the hazard of special concession, which was a hazard we had to accept under the security conditions. We feel this is all over. There has been an $8 price established. I think everyone accepts the fact that there were differences between the early negotiations and that the present negotiations should be relatively on an equal plane. There should no longer be the possibility of special concession in contract negotiations. This would be precluded if agreements were made public.

Representative HOLIFIELD. Are you telling me that there is a flat price for big producers and small producers?

Mr. WELLER. As you know, the Commission announced the $8 price. There are some differences between the large producers and the small producers.

Representative HOLIFIELD. Is it generally the fact that the small producers get more for their product than the large producers?

Mr. WELLER. Are you speaking about the present contracts which expire at 1962?

Representative HOLIFIELD. Yes.

Mr. WELLER. Yes; this is true, so far as I know.

Representative HOLIFIELD. What would be gained by making them public? I am seeking the reasons for this policy and your reason for asking that they be made public. It is all past history. The contracts are signed. Why should you know, for instance, or why should some company A know that they are selling their product for $11 under the contract while company B is selling theirs for $12? Maybe they were negotiated at different times and they are matters of contract. It would be hardly be ethical to go back on a contract. There were different urgencies at the time the contract was signed.

Mr. WELLER. Certainly. I believe the approach is the wrong approach. I should like to ask the question: Why should they not be made public?

Representative HOLIFIELD. All right. I don't know why they should not be, nor do I know why they should be. If it is just back-fence curiosity on your part, knowing what your competitors are getting, I see no reason why that curiosity should be assuaged.

Mr. WELLER. It is far from back-fence curiosity. I believe an independent producer should be able to see the contract under which concentrates sold from his ore production are sold to the U.S. Government. If he can't see this instrument, I think he is in a position of being forced to be blindly dependent upon a market he doesn't understand. Then we come along with a change in program and the Government expects this producer to accept a change of program. This is extremely shortsighted, it seems to me, with regard to the independent's business requirements.

Representative HOLIFIELD. You are asking for a carrythrough on your production from yourself to the mill and from the mill to the Government. Is that what you are saying? This is of one particular company. I won't say yours.

Mr. WELLER. I don't represent a company. I represent industry members, both millers and independent operators.

Representative HOLIFIELD. Are you asking that all of these steps of all of the companies be public?

Mr. WELLER. Absolutely. We owe this not only to the industry, but to the general public. This is public business; it is healthier that the public have the opportunity to scrutinize it.

Representative HOLIFIELD. I can understand why each company would want to follow the financial steps in regard to its own production through the mill to the Government, but I can't understand why they would necessarily want to know each step of all of their competitors.

Mr. WELLER. I don't think there is too much need of airing this information from the standpoint of competitive relationships of the mills. I think they pretty well know this already. There is far more information known by one mill about the other mill's contract than there is by an independent about the contract of a mill to which his ore is tributary.

Representative HOLIFIELD. I am not critical. I am just trying to find out what the reasons are.

Mr. WELLER. I don't believe you are, sir. I appreciate your questions.

Chairman ANDERSON. Let us see if we can change it a little bit now. Here is company 6, we will say. It sells its ore to a large organization such as the Anaconda or some of those mines. If it finds out that Kerr-McGee or Anaconda, or somebody else, has a pretty good deal, will it be able to change the price it gets under its existing contract already executed with the Federal Government?

Mr. WELLER. You are talking about Anaconda's contract?

Chairman ANDERSON. No. You want to make these contracts public. I am trying to find out the value of making them public. Will any little company have the price it gets for ore raised one penny even if it is made public?

Mr. WELLER. No, sir.

Chairman ANDERSON. Then what benefit does it get?

Mr. WELLER. Here is one very definite benefit. There is one milling company operating under a contract which had no provision in its contract forcing it to buy independent ore, but it did so by policy, until it got to the point where it found that it either had to go ahead and finish out its own ores under the prospect that it might not be able to continue to operate after its contract terminates or take independent ore and have a lot of ore of its own in the ground when its contract expired. The independent should have known of these market conditions.

Chairman ANDERSON. What value would there have been in making public the fact that its contract did not force it to buy ore from anybody?

Mr. WELLER. Then the independent which developed mining properties and spent a great deal of money in developing these properties would at least know that their investments were being made with some degree of jeopardy because their market was not assured.

Chairman ANDERSON. They already know that, because of the first 2,000 mines which got started. How many of them are in operation today? Less than a hundred. So there was some jeopardy in the business generally. I am trying to find out how they benefit. What value do they get by knowing they are in jeopardy?

Mr. WELLER. Any businessman that goes into business tries to make an accurate appraisal of his market before he makes his investment. Why should this information not be available?

Chairman ANDERSON. We were just talking about the Ford Motor Co. not knowing what its market is going to be. They still make cars, whether it will be a 6 or 7 million market.

Mr. WELLER. That is just the point. The Ford Motor Co. knows it will be either 6 or 7 million.

Chairman ANDERSON. But it does not know which it will be.

Mr. WELLER. Because of precedent and trends, which are very reliable statistical things. There is no such statistical record with regard to the uranium industry, and we have to depend on Government policy and we have to know as much about that policy as possible.

Chairman ANDERSON. I don't see how putting these contracts out in the open will be an advantage.

Mr. WELLER. I don't know that I can say anything further to substantiate my position, sir. I simply reiterate: Why should they not be made public? They are public business and the program is no longer classified.

Senator AIKEN. I might say, Mr. Chairman, that Henry Ford did not have much to go on in the way of statistical records when he started making cars, but he did pretty well in spite of it.

Chairman ANDERSON. This is a matter that has come up several times, that this is public business and it all ought to be out in the open.

Mr. WELLER. Yes, sir.

Chairman ANDERSON. Sometimes that happens and sometimes it does not. I have not seen anyone ask that all the contracts between the Defense Department and subcontractors be published.

Mr. WELLER. Possibly for security reasons.

Representative HOSMER. I would like to say I share the views expressed by the committee members this morning. I don't think you have in any way satisfied our curiosity as to why these things should be made public.

Representative HOLIFIELD. I see no reason why they should not be, myself.

Mr. WELLER. Very good. This is all we wanted to get from you.

Representative HOLIFIELD. I have to be fair and say I see no reason why they should not be. I don't want the record to stand that I have taken a position in one way or another on this, because I just don't see the point.

Chairman ANDERSON. You may proceed.

EVALUATION OF FUTURE MARKETS FOR URANIUM

Mr. WELLER. On several occasions over the past 2 years, AEC spokesmen have advised the uranium industry that programs of the industry to develop further reserves beyond those qualified for production through 1966 must be based upon "confidence in the future market for atomic power."

Mr. Chairman, the Uranium Institute has conducted many studies on the prospectus for uranium. Not too long ago, we held a 2-day symposium on the subject of "Future Markets for Uranium." We have had to come to the conclusion that these studies are illuminating but that their results are quite transitory. A continuing study made in a consistent manner would have far greater value.

We have looked to official expressions from leaders in high places, and on December 8, 1953, we find that President Eisenhower told the United Nations that our "(atomic) capability, already proved, is here—now—today." The President went on to prophesy:

> Who can doubt, if the entire body of the world scientists and engineers had adequate amounts of fissionable material with which to test and develop their ideas, that this capability would rapidly be transformed into universal, efficient, and economic usage?

We also have the expression contained in the President's budget message before this Congress advising us that—

> substantial increases for research and development activities will be offset by reductions in procurement of uranium ore concentrates from United States and Canadian producers. These reductions will bring ore supplies into better balance with production requirements.

In studying the prospectus for the industry, in the years immediately ahead of us we were very gratified that the Director of Raw Materials for the Atomic Energy Commission included a chart in a major address which he made last April which set forth the uranium deliveries and commitments of the Atomic Energy Commission, raw materials procurement program for fiscal years 1956 through the first half of 1967.

I referred to this chart at the beginning of my testimony. I would like to ask if this could be included in the record.

Chairman ANDERSON. I think there was some argument at one time with the AEC about the use of that chart. I think it is all cleared now. If it is cleared up, it will be included in the record.

Mr. WELLER. Thank you very much.

(The chart referred to appears on p. 274.)

Mr. WELLER. We were, therefore, quite shocked to learn in studies which the institute has been conducting in the past few weeks that current projections of the Atomic Energy Commission reflect reduced figures for the projected years, fiscal years 1961–62–63, amounting to a total reduction of 1,000 tons of U_3O_8 which the Commission now has lopped off its anticipated obligation to the domestic industry. At the same time, we find that anticipated obligations to the industry in Canada has been increased by 2,720 tons over projections made in April 1959.

(A letter dated February 24, 1960, to Mr. Weller from Senator Anderson, regarding the above statement, and the UIA study, follows:)

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
Washington, D. C., February 24, 1960.

Mr. GORDON A. WELLER,
Executive Vice President,
Uranium Institute of America,
Grand Junction, Colo.

DEAR MR. WELLER: During your testimony before the Joint Committee on February 19, 1960, you stated:

"We were, therefore, quite shocked to learn, in studies which the Institute has been conducting in the past few weeks, that current projections of the Atomic Energy Commission reflect reduced figures for the projected years, fiscal year 1961, 1962, and 1963, amounting to a total reduction of 1,000 tons of U_3O_8 which the Commission now has lopped off its anticipated obligation to the domestic industry. At the same time, we find that anticipated obligations to the industry in Canada has been increased by 2,720 tons over projections made in April 1959."

The Joint Committee staff, following your testimony, immediately requested the AEC to comment on these figures, and a copy of the AEC letter dated February 19, 1960, was furnished you on your visit to the Joint Committee offices on February 24, 1960. In order to explore this matter further, we believe it will be necessary to obtain copies of the institute studies referred to in your testimony, and further details as to the figures you mentioned. Therefore, it is requested that you forward two copies of the institute studies to the Joint Committee, including an explanation of the derivation of the figures of 1,000 tons and 2,720 tons mentioned in your testimony.

Sincerely yours,

CLINTON P. ANDERSON, *Chairman.*

URANIUM INSTITUTE OF AMERICA,
Grand Junction, Colo., February 29, 1960.

Hon. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. CHAIRMAN: In accordance with your request of February 24, we will be happy to transmit the specific studies relating to our contentions contained in our testimony of February 19.

Conferences held with Commission officials in Washington since our testimony substantiate our position with respect to the domestic industry. A question has developed, however, in regard to the exact magnitude of the Canadian projection increases. We are currently reviewing this phase of our studies.

We anticipate that this material can be put in form to transmit to you within the coming week.

Despite this further review, however, we are assured that these studies will show that a comparison of two projections made by the AEC—one released in April 1959 and the other received in December 1959—reflect substantial reductions for scheduled uranium concentrate receipts from the domestic industry, and even more substantial increases in anticipated total receipts from the Canadian industry.

The interest of your committee in the facts contained in the Uranium Institute testimony rendered before your recent "202 hearings" is greatly appreciated.

Most respectfully,

GORDON A. WELLER.

URANIUM INSTITUTE OF AMERICA,
Grand Junction, Colo., March 8, 1960.

Hon. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
U.S. Congress, Washington, D.C.

DEAR SENATOR ANDERSON: In further response to your letter of February 24, 1960, we respectfully submit two copies of Uranium Institute studies amending and supplementing our testimony of February 19, 1960.

We appreciate the interest that you and the other members of the Joint Committee have taken in the various matters dealt with in our testimony, and we wish to assure you of our desire to fulfill any further requests that might stem from your further studies of the raw materials program of the AEC.

Most respectfully,

GORDON A. WELLER.

SUPPLEMENTARY STUDIES AND COMMENTS BY GORDON A. WELLER, EXECUTIVE VICE PRESIDENT, URANIUM INSTITUTE OF AMERICA

Amending and extending testimony before the Joint Committee on Atomic Energy, U.S. Congress, hearings on development, growth, and state of the atomic energy industry

MARCH 8, 1960.

1. On February 19, 1960, the Uranium Institute of America rendered testimony before the Joint Committee on Atomic Energy on the state of development of the uranium industry. In this testimony, we compared projections which had been prepared by the Atomic Energy Commission on two different occasions during the past calendar year. The first projection was prepared and released in April of 1959, and the second projection was prepared in Octobr 1959, and secured for purposes of study in December of 1959. We testified that a comparison of these two projections indicated a decrease in the expected deliveries from the domestic industry of 1,000 tons of U_3O_8 and an increase of expected deliveries from the uranium industry in Canada amounting to 2,720 tons. On February 24, 1960, Chairman Anderson asked for UIA studies supporting these figures.

2. On February 23, 1960, following the testimony before the Joint Committee on Atomic Energy, a conference was held with officials with the Atomic Energy Commission for the purpose of reconciling the Uranium Institute interpretation with the views of those of the Atomic Energy Commission. On February 24, 1960, we received a copy of the letter of explanation from AEC General Manager Luedecke addressed to Chairman Anderson, providing further illumina-

tion to the reasons behind the difference in the two projections. Since returning to the West, we have also been in contact with the Grand Junction Operations Office of the AEC for the purpose of further exploring the basis of the two projections.

3. The projections and information sources involved in this discussion and in the testimony of the institute before the Joint Committee are included in the appendix of this report as follows:

Exhibit A: Bar graph entitled "Uranium Deliveries and Commitments," released as a part of the address of the Director of Raw Materials, AEC, on April 17, 1959. Chart shows actual uranium deliveries for fiscal years 1956–58, and commitment for deliveries for fiscal years 1959-first half of 1967. Bar graphs are segmented to show amounts committed to domestic industry, to Canadian industry and to oversea sources.

Exhibit B: "Schedule of Estimated Deliveries and Cost of U_3O_8 Concentrates by Source and Fiscal Year for Period July 1, 1959, Through December 31, 1966." This tabulation was received from the Raw Materials Division on December 3, 1959.

Exhibit C: "Schedule of Canadian Contract Amendments Executed in Early 1959 and Computations of Canadian Uranium Procurement Increase Since November 24, 1958."

Exhibit D: Copy of letter from AEC General Manager A. R. Luedecke to Senator Clinton P. Anderson, chairman, Joint Committee on Atomic Energy, dated February 19, 1960, and released to Uranium Institute on February 24, 1960.

SUMMARY OF FINDINGS

4. As a result of these conferences and further studies, the Uranium Institute submits the following:

(*a*) The reduction in estimated deliveries expected from the domestic industry as projected on exhibit B is 600 tons, compared with that projected on exhibit A, rather than the 1,000-ton differential submitted in our testimony.

(*b*) While we initially submitted that the increase for Canada was 2,720 tons, we now acknowledge that the increase of the projection of exhibit B as compared with the projection of exhibit A for the Canadian industry is more properly 1,726 tons increase.

(*c*) We further submit that the increase referred to in paragraph *b* above represents a cost to the U.S. Government of $38 million. Four contracts to procure additional amounts of U_3O_8 negotiated early in 1959 by the Commission with the Canadians (see exhibit C) amounts to $71 million, making a total of $109 million of increased commitments the AEC has made with Canada since the November 24, 1958, announcement placed severe restriction on the development of the domestic industry.

(*d*) We further submit that if the Commission permitted all mills now authorized and under contract to operate at capacity through 1966 without imposition of the presently drawn arbitrary and restrictive definitions as to eligible ore reserves, the increased cost to the American Government over the present program as projected on exhibit B would be in the amount of $108 million—$1 million less than the increases which have been authorized for Canada since the imposition of the November 24, 1958, announcement.

SUPPORTING CALCULATIONS

5. Comparison of domestic industry projections:

Fiscal year	Exhibit A projection	Exhibit B projection	Increase (+) or decrease (−)
1960	17,300	17,700	+400
1961	18,500	18,100	−400
1962	18,200	17,800	−400
1963	18,000	17,800	−200
Total	72,000	71,400	−600

The increase in projections for fiscal year 1960 between exhibit A and B was ignored in our calculations for the testimony because it was assumed that this increase was a result of contract increases in Wyoming and Colorado front range which were not reflected in the April 1959 projection. We now find that this increase was included in the April 1959 projection, and therefore should be applied against the 1,000-ton decrease for fiscal years 1961, 1962, and 1963.

6. Projections for Canada:

Fiscal year	Exhibit A projection	Exhibit B projection	Increase (+) or decrease (−)
	Tons	*Tons*	*Tons*
1960	13,870	13,150	−720
1961	13,500	11,400	−2,100
1962	11,400	10,000	−1,400
1963	2,000	3,870	+1,870
1964		2,000	+2,000
1965		2,300	+2,300
Total	40,770	42,720	+1,950

It was also noted by General Luedecke in his letter of February 19, 1960, that the deliveries from Canada in fiscal year 1959 fell short of their expectations: Our files reflect the following data:

	Tons
Scheduled deliveries	13,730
Actual deliveries	13,506
Shortfall of deliveries	224

Difference of 1,950 tons, as noted above, less shortfall for 1959, 224 tons equals net increase for Canada between the two projections, 1,726 tons. Whatever be the explanation, and taking into account the shortfall on delivery of uranium concentrates in fiscal year 1959 from Canada, we submit on the basis of the most accurate information that can be secured from the AEC that the exhibit B projections have increased the Canadian "take" in the aggregate of 1,726 tons over the projections of April 1959, exhibit A.

BASIC CONSIDERATIONS IN STUDY OF CONCENTRATE PRODUCTION

7. Short-term fluctuations in actual total production of uranium concentrate as compared with projection schedules may be due to one of three factors:

(*a*) Older domestic mill contracts placed greater emphasis on tonnage of ore throughput than in pounds of concentrate produced. Fluctuations could therefore be due to variations in grade of ore feed and rate of recovery of uranium from ore.

(*b*) Operating difficulties have occasionally prevented mills from meeting production targets for a stipulated period.

(*c*) In earlier periods of industry operation, AEC frequently gave permission to mills to overrun their contracts in order to secure additional quantities of uranium.

8. Long-term trends in uranium concentrate production are the result of two opposing forces:

(*a*) New mill capacity being contracted for, resulting in construction and early period of operation shakedown tests, and finally coming up to full operation, thereby increasing total capacity of the industry.

(*b*) Depletion of tributary reserves resulting in lower grades of feed and reduced quantity of throughput.

9. We are advised that the April 1959 projections included all contract increases for the State of Wyoming, and Colorado front range, as contained in the April 2, 1958, report of the AEC on the "Domestic Mining and Milling Problems Resulting From Limitation on Additional Milling Capacity."

10. In regard to the 1,000 tons aggregate reduction for fiscal year 1961, 1962, and 1963, we note the following explanation in General Luedecke's letter of February 19, 1960:

"All tabulations and total figures which we have issued either to the Joint Committee or to the public with regard to domestic procurement have been based on the summation of quantities covered by firm contracts plus our estimate of the quantities which we are planning to purchase under the program announced November 24, 1958. We have not as yet fully assessed the reserves at November 24, 1958, nor entered into contracts for the purchase of uranium derived from some of these reserves."

Attention must be called to the fact that the November 24, 1958, announcement concerned the markets for uranium after March 31, 1962. Accordingly, all of fiscal year 1961 and three-quarters of fiscal year 1962 should not be affected by the change of administrative procedure resulting from the November 24, 1958, announcement.

11. General Luedecke also states in his letter:

"Further, as the committee knows, we have excess uranium scheduled for delivery over the next 3 years, and are negotiating stretchouts with domestic producers involving later delivery of the quantities deferred. Such deferrals do not affect the quantity of uranium the Commission is firmly obligated to purchase under these contracts."

We are advised that the April 1959 projection included the Anaconda stretchout, reducing the operating capacity of that plant from 3,500 tons per day on a 7-day-week basis to 3,000 tons per day on a 6-day-week basis. No other stretchouts have thus far been announced.

12. A comparison of the two projections for fiscal years 1960 through first half of 1967 is as follows:

Fiscal year	Exhibit A projection	Exhibit B projection	Increase (+) or decrease (−)
	Tons	*Tons*	*Tons*
1960	17,300	17,700	+400
1961	18,500	18,100	−400
1962	18,200	17,800	−400
1963	18,000	17,800	−200
1964	17,500	17,500	0
1965	17,500	17,500	0
1966	17,300	17,300	0
1st half 1967	8,100	8,100	0
Total	132,400	131,800	−600

It will be noted in the above comparison of the two projections that no compensating increase in the years after fiscal year 1963 were made for the reductions in fiscal years 1962 and 1963.

CONCLUSION

13. We find that the decreases for the domestic industry in the fiscal years 1961, 1962, and 1963 amount to plus or minus 2 percent, which may well be within the tolerance of normal operating fluctuations.

14. The aggregate increase for the Canadian industry totals 4 percent over all fiscal years 1960 through 1965. We submit this is beyond such tolerance.

15. We must respectfully protest any justification for an increase in Canadian procurement on the basis of restoration of former Canadian commitments as set forth in the next to last paragraph of General Luedecke's letter:

"Within respect to item 5 above, we should like to point out that Eldorado Mining & Refining, Ltd., had in the past withdrawn for its own use substantial tonnages of U_3O_8, thus reducing our obligation by that amount. With a stretchout in production and the existence of excess productive capacity, it was apparent that Eldorado need not, and probably would not, draw upon AEC deliveries for any future requirement. Thus the amount which Eldorado was previously expected to take was added to the prior estimate."

It must be noted that the AEC increased its obligations to Canada in the amount of $71 million in early 1959 after a severe restriction was placed on the domestic industry. Any further restoration as set forth in General Luedecke's analysis accordingly is fallacious.

16. With regard to General Luedecke's last paragraph, we, too, feel it unfortunate that the Commission is not aware of the strong feeling developing in the domestic industry in regard to the manner of administration of the raw materials program. On January 11, 1960, we contacted the Raw Materials Division and asked for new projections which reflected the changes since the April 1969 projections. We were advised that no new projections had thus far been prepared or were available to the public.

At the same time, we had the projection which had been secured by an associate in the Atomic Energy industry not affiliated with the raw materials interests. This person was advised that the projection was public information. We must submit that such indiscretion in the handling of public information does not inspire the confidence that would cause the type of counsel which General Luedecke invites.

17. In our testimony before the Joint Committee on February 19, we made the following statement:

"Mr. Chairman, I submit that this experience makes it absolutely obvious and mandatory that every vestige of secrecy must now be stripped from the raw materials program of the Atomic Energy Commission, and that the history of all contracts and obligations and the terms of those contracts be fully documented for public inspection."

The further study conducted since this statement was made reenforces our support of this statement.

18. The raw materials program of the AEC now exceeds $600 million per year, yet the Raw Materials Subcommittee has not held a public hearing intended to review the specific problems of the uranium industry nor the manner of its administration by the Atomic Energy Commission. We find that three hearings were held in 1958, one in 1959, by the Raw Materials Subcommittee, but none of these hearings were open to the public, nor were industry representatives permitted to be present. In 1959, we protested the conduct of such executive hearings, and we persist in this position. By the same token, we urge that public hearings be scheduled that will permit a complete review of the manner in which the raw materials program is being conducted.

Most respectfully,

GORDON A. WELLER.

Exhibit A

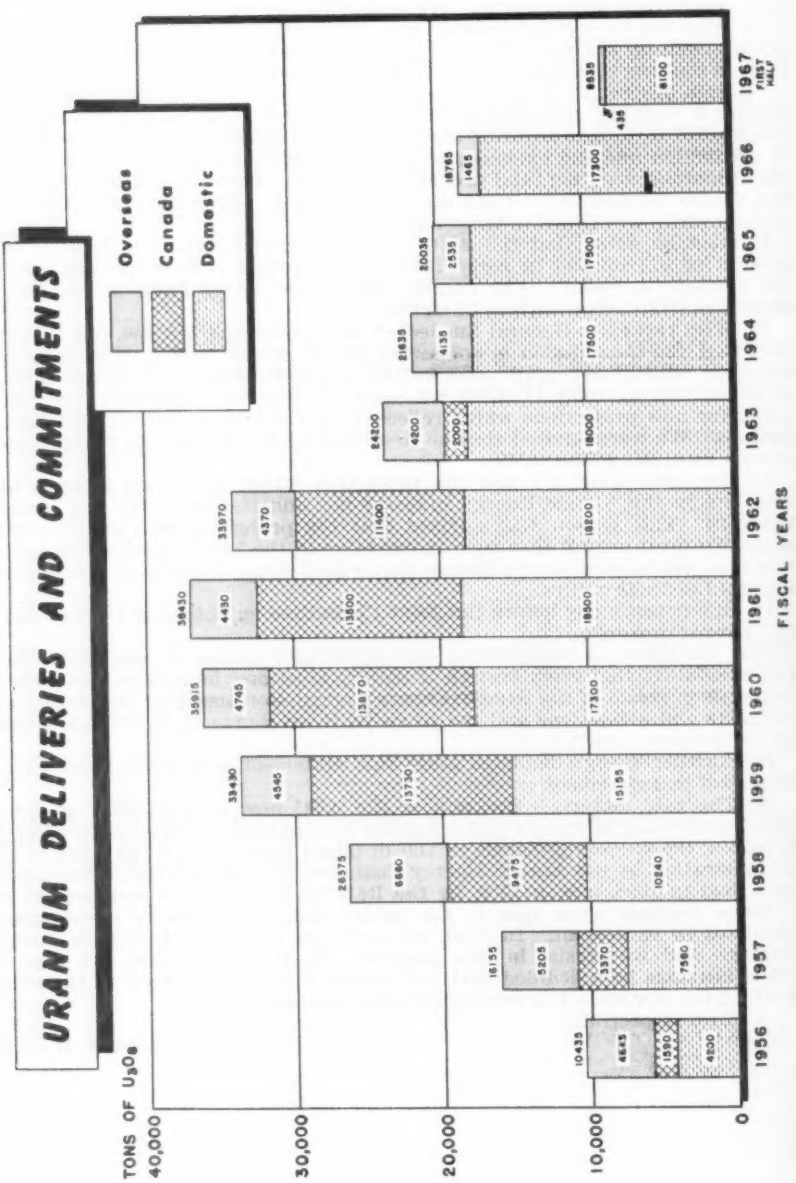

URANIUM DELIVERIES AND COMMITMENTS
Overseas
Canada
Domestic
TONS OF U_3O_8
40,000
30,000
20,000
10,000
0
FISCAL YEARS
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
FIRST HALF
10435
4645
1590
4230
16135
5205
3370
7560
26375
6660
9475
10240
33490
4545
13730
15215
35915
4745
13870
17300
36430
4430
13800
18500
33970
4370
11400
18200
24200
4200
2000
18000
21635
4135
17500
20035
2535
17500
18765
1465
17300
435
8535
8100

EXHIBIT B

Schedule of estimated deliveries and cost of U_3O_8 concentrates, by source and fiscal year, for period July 1, 1959 through Dec. 31, 1966

1. ESTIMATED URANIUM DELIVERIES AND COST BY SOURCES TO UNITED STATES

[Cost expressed in millions]

	1960	1961	1962	1963	1964	1965	1966	1st half 1967	Grand total
Domestic:									
Tons	17,700	18,100	17,800	17,800	17,500	17,500	17,300	8,100	131,800
Cost	$311.3	$312.3	$304.4	$285.5	$280.7	$280.7	$278	$130.1	$2,183
Price per pound	$8.79	$8.63	$8.55	$8.02	$8.02	$8.02	$8.02	$8.02	$8.28
Canada:									
Tons	13,150	11,400	10,000	3,870	2,000	2,300	----	----	42,720
Cost	$289.9	$249.6	$215	$78.3	$42.2	$47.6	----	----	$922.6
Price per pound	$11.02	$10.95	$10.75	$10.12	$10.55	$10.35	----	----	$10.78
Overseas:									
Tons	4,380	4,470	4,370	4,200	4,135	2,535	1,465	435	25,990
Cost	$105.3	$108.1	$105.8	$100.8	$99.2	$60.8	$35.1	$10.4	$625.5
Price per pound	$12.02	$12.10	$12.10	$12	$12	$12	$12	$12	$12.03
Total:									
Tons	35,230	33,970	32,170	25,870	23,635	22,335	18,765	8,535	200,510
Cost	$706.5	$670.1	$625.2	$464.6	$422.1	$389.1	$313.1	$140.5	$3,731.1
Price per pound	$10.03	$9.86	$9.72	$8.98	$8.93	$8.71	$8.34	$8.23	$9.30

2. LENGTH OF CONTRACTS

Domestic.—Program expires on December 31, 1966. Forecast of estimated deliveries is based on quantities presently under contract together with the minimum quantities expected to be purchased under the domestic program announced November 24, 1958.

Canada.—Present contract expires March 31, 1963, with option to extend period of deliveries to December 31, 1966. Forecast of delivery rates based on estimated minimum deferral.

Overseas.—Belgian Congo contract expires December 31, 1960. Portugal deliveries should be completed by December 1961. Australia: Rum Jungle contract expires January 7, 1963; Radium Hill contract expires January 1, 1962. South African contract continues to December 31, 1966, with a declining rate of production beginning in fiscal year 1964 when certain of the mines will have completed their 10-year contracts.

3. COSTS, BEFORE AND AFTER AMORTIZATION OF PLANTS

Forecast of costs to the Commission are based on terms of Commission contracts and outstanding domestic commitments. Under our domestic program prices to be paid are based on the established price of $8 per pound after March 31, 1962. It is contemplated at this time that purchases from foreign sources will be only those presently under contract.

Source: U.S. Atomic Energy Commission, Division of Raw Materials. All information on this form received Dec. 3, 1959.

EXHIBIT C

Schedule of Canadian contract amendments executed in early 1959

Producer	Pounds U_3O_8	Price per pound U_3O_8	Value of contract
	Thousands		*Thousands*
Gunnar Mines, Ltd	4,500	[1] $8.75	$37,400
Pronto Uranium Mines, Ltd	1,508	8.00	12,064
Algom Uranium Mines, Ltd	2,456	8.00	19,648
Bicroft Uranium Mines, Ltd	260	8.00	2,080
Total commitment extension	8,724	----	71,192

[1] Canadian dollars.

Computations of Canadian uranium procurement increase since Nov. 24, 1958

	Million
1,726 tons (par. 6) increase over April 1959 projections at estimated price of $11 per pound	$38
Contract amendments noted in tabulation above	71
Total increased Canadian uranium procurement since Nov. 24, 1958	109

Computation of fund requirement to permit U.S. industry to operate at full capacity through 1966 as compared with exhibit B projection

	Million
18,500 tons per year, fiscal year 1961 through 1st half 1967, 6.5 years at average price of $8.20	$1,980
Plus 17,700 tons for fiscal year 1960 (per exhibit B)	311
Total fund requirement for capacity operation of U.S. industry	2,291
Less fund now scheduled (exhibit B)	2,183
Fund increase requirement over that now scheduled	108

Note that the above figure is $1 million less than increases which have to be awarded the Canadian industry since the November 24, 1958, announcement.

Representative HOLIFIELD. I am not going to contradict what you have said there because you undoubtedly have the right figures, but my understanding of the Canadian contract procedure was that where we had a certain amount of this ore contracted, we were obligated to accept it before the contracts expired in 1962–63. Now we have stretched this out over another few years, varying in different contract cases, which would have the automatic result of being beneficial to the Canadians in that they could continue to operate and kind of gradually take the blow that they would have as a complete shutoff in 1962 or 1963, and that the result, as far as we are concerned here at home, is that the annual import would be cut down and therefore it would not affect the domestic market as much for the next couple or 3 years as if they had gone ahead and fulfilled their contract on the original terms. Is that true?

Mr. WELLER. Yes, sir.

Representative HOLIFIELD. Then is this just a monthly variation which goes up, that you refer to, because if it is that is not so important. The important thing, it would seem to me, that annually for the next 2 years we are going to take less and in the aggregate we are not going to take any more than we would take in the next 2 years.

Mr. WELLER. I am comparing projections, those made in April 1959 with those made at the end of 1959, the total commitments which the Commission considers it has with both the domestic industry and Canada. I find in totaling all of these figures that the Commission has now reduced the domestic industry by 1,000 tons and it has increased the Canadian obligations or what it considers obligations by the amount of 2,720 tons over that which they said they had in April of 1959.

Representative HOLIFIELD. At the same time they are not taking as much from the Canadians as they would have been obligated?

Mr. WELLER. On a yearly basis; no.

Chairman ANDERSON. Let me get into this just a moment because this is something I spent a little time on. Is it not true that the Canadians negotiated for some time on this and originally asked for a

bonus in consideration of their turning down some of their present production? In other words, the first chart that they presented, as I recall it, was that if the Canadians dropped off a thousand tons in 1961 and 1962 and 1963, they would get 2,000 tons restored to them later for each thousand tons they took off.

That was rejected by the Atomic Energy Commission. I am not trying to use the exact figure, but they came up with 1½ to 1. The final adjustment was based on a 1-to-1 basis.

Mr. WELLER. That was the announcement of the Commission at the time the Canadian contract adjustment was made in November.

Chairman ANDERSON. I am sure that is correct. How do you say that they were increased 2,720 tons over the projections made if you mean only that they had agreed to take deliveries at a certain rate, cut back those deliveries for the next few years, and agree to take them in subsequent years.

Mr. WELLER. I am not talking about any change of commitments that would come under the stretchout concept, or of borrowing from one year and adding on in another. I am talking about the aggregate of total commitments over the entire procurement program.

Chairman ANDERSON. Let me read it.

At the same time, we find that anticipated obligations to the industry in Canada has been increased by 2,720 tons over projections made in April 1959.

Mr. WELLER. Yes, sir.

Chairman ANDERSON. If it was on a 1-for-1 basis it was not an increase at all.

Mr. WELLER. They announced it was a 1-for-1 basis when they made the announcement. But when I add up the figures I find that there is 2,720 tons ahead for Canada, 1,000 tons less for the United States.

Mr. RAMEY. What are those total figures?

Mr. WELLER. I would be very happy to supply those figures for the record.

Representative HOLIFIELD. Does your statement refer to the annual obligation or are you just referring to the one month of April?

Mr. WELLER. No. I am talking about projections for the entire procurement program which were made as of April 1959.

Representative HOLIFIELD. I think this is a very important statement, Mr. Weller, and you want to be sure to back that up. Mr. McCone has assured us, or I thought he assured us—I am not trying to impute any bad faith to him—that the trade was an even trade. It was not 2,700 tons more. If it is 2,700 tons more, then he has either been misled or we have been misled.

Mr. WELLER. I certainly don't want to impugn Mr. McCone's integrity because I think he is a very fine individual.

Representative ASPINALL. Mr. Chairman, may I make this statement: Mr. Weller brought this to my attention several weeks ago, and he has undoubtedly been working on this computation since that time. I shall welcome his statement. If I remember correctly, I told you that I thought Mr. McCone had made a statement that it was a trade of one for one.

Mr. WELLER. That is correct.

Representative ASPINALL. You advised me that in your figures it didn't come out quite that well for the domestic producers.

Mr. WELLER. This is correct. I testified before the Joint Economic Committee last October and referred to four contract extensions which the Commission did negotiate with the Canadians and which are referred to in the annual report for 1959. The total of these contract extensions amounted to some 4,000 tons. But when I compare the totals of the projections set up in April of 1959, with projections which had been made at the latter part of November, I find that the difference is 2,720 tons in the Canadians' favor, 1,000 tons to the detriment of the domestic industry.

Chairman ANDERSON. Let us see if Mr. Toll, the counsel for the committee, can make some statement that will help us.

Mr. TOLL. I think Mr. Weller can help me out here. I believe this has nothing to do with the stretchout. It is a reflection of obligations that were made by the AEC to Canada prior to 1952, but the exact amounts were not determined until about 1959.

Mr. WELLER. Mr. Toll, I am at a loss to try to understand how these figures, as we received them, are arrived at. You are in a far better position to observe than I. I know about the contract extensions made to four companies in Canada. I have been critical of those extensions. Then I see the result as the figures come out. I don't know why they come out the way they do.

Mr. TOLL. I think, Mr. Chairman, we could get a statement from the AEC that could clear up what this was, but it was a separate transaction from the stretchout.

(A letter from A. R. Luedecke, General Manager, AEC, regarding the preceding discussion, follows:)

U.S. ATOMIC ENERGY COMMISSION,
February 19, 1960.

Subject: Testimony by Gordon A. Weller at 202 hearings, February 19, 1960.

Hon. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Congress of the United States.

DEAR SENATOR ANDERSON: We have not as yet had an opportunity to study the full text of Mr. Weller's statement, but note that, among other things, he made the following remarks:

"In studying the prospectus for the industry, in the years immediately ahead of us, we were very gratified that the Director of Raw Materials for the Atomic Energy Commission included a chart in a major address which he made last April which set forth the uranium deliveries and commitments of the Atomic Energy Commission raw materials procurement program for fiscal years 1956 through the first half of 1967.

"We were therefore quite shocked to learn in studies which the institute has been conducting in the past few weeks, that current projections of the Atomic Energy Commission reflect reduced figures for the projected years, fiscal years 1961–62 and 1963 amounting to a total reduction of 1,000 tons of U_3O_8 which the Commission now has lopped off its anticipated obligations to the domestic industry. At the same time, we find that anticipated obligations to the industry in Canada has been increased by 2,720 tons over projections made in April 1959."

With respect to the first statement that domestic receipts have been reduced by 1,000 tons of U_3O_8 in fiscal years 1961–62 and 1963, and that this amount has been lopped off of our anticipated obligation to the domestic industry, we have the following comment. All tabulations and total figures which we have issued either to the Joint Committee or to the public with regard to domestic procurement have been based on the summation of quantities covered by firm contracts, plus our estimate of the quantities which we are planning to purchase under the program announced November 24, 1958. We have not as yet fully assessed the reserves at November 24, 1958, nor entered into contracts for the purchase of uranium derived from some of these reserves. Our estimates of the Commission's total domestic purchases will be revised from time to time as more contracts

are entered into and more facts become available. We are unable to check the figure of 1,000 tons in the 3 fiscal years mentioned. Further, as the committee knows, we have excess uranium scheduled for delivery over the next 3 years and are negotiating stretchouts with domestic producers involving later delivery of the quantities deferred. Such deferrals do not affect the quantity of uranium the Commission is firmly obligated to purchase under these contracts.

The second point in Mr. Weller's statement which gives us concern is the implication that we have increased our obligations to purchase Canadian uranium in the amount of 2,720 tons over projections made in April 1959. As the committee has been advised, we have not increased Canadian purchase obligations. Also, we reemphasize that the Canadian stretchout involved no additional uranium purchases. It is unfortunate, however, that the figures Mr. Weller is citing could be construed to indicate that this was the case. On February 16, 1959, we furnished the committee a tabulation in connection with a prepared statement indicating that our total remaining Canadian uranium commitments beginning fiscal year 1960 amounted to 40,770 tons of U_3O_8. This figure could also have been totaled from a tabulation appended to a talk given by the Director of Raw Materials in Wyoming on April 17, 1959, which was apparently Mr. Weller's source. This figure excluded material on which provisional payments had been made but which had not yet been delivered to the AEC. It also excluded the quantity of material which we at that time estimated the Canadian Government might take for its own use from our contract quantities. It ignored intransit inventory.

Our last advice to the Joint Committee on October 12, 1959, gave a figure of 42,720 tons—an apparent increase of 1,950 tons U_3O_8. This reflected our calculation of undelivered quantities under the Canadian contracts at the beginning of fiscal year 1960. The two figures are reconciled as follows:

[Tons U_3O_8]

1. February estimate of commitments—fiscal year 1960 through 1st half fiscal year 1967	40,770
2. Short fall of deliveries in fiscal year 1959	225
3. Inventory at Port Hope, Ontario, refinery for refining and delivery to AEC as UO_3 (at end fiscal year 1959). Payments for U_3O_8 in concentrate are made when received at Port Hope	765
4. Concentrates in transit to the U.S. (at end fiscal year 1959)	485
5. Restore estimated future Canadian withdrawals	475
Total	42,720

With respect to item 5 above, we should like to point out that Eldorado Mining & Refining Ltd., had in the past withdrawn for its own use substantial tonnages of U_3O_8, thus reducing our obligations by that amount. With a stretchout in production and the existence of excess productive capacity, it was apparent that Eldorado need not, and probably would not, draw upon AEC deliveries for any future requirement. Thus the amount which Eldorado was previously expected to take was added to the prior estimate.

We can understand how Mr. Weller might have interpreted the change in estimate as an increase in obligations, and feel it unfortunate that we were not aware he had reached the conclusion presented to the committee. We have been in touch with Mr. Weller in an attempt to obtain the basis for the figures given the committee. However, Mr. Weller states that the necessary figures are not immediately available to him, but that he will discuss them with us next week.

Sincerely yours,

A. R. LUEDECKE, *General Manager.*

Chairman ANDERSON. I am very glad to have that statement, because I have had one statement from the AEC. But I would be glad to have another. That first statement from the AEC was that as a result of the stretchout, there was no increase in the amount coming from Canada.

If Mr. Weller can prove that it is 2,720 tons more, then we are going to have a very interesting session.

Representative HOSMER. Where do you get these figures that you total up, Mr. Weller? That is, the April and November figures.

Mr. WELLER. I got these from a person who got them directly from the Director of Raw Materials.

Representative HOSMER. Then they are AEC figures?

Mr. WELLER. Yes, sir.

Chairman ANDERSON. We will ask the AEC for a comment on that because this is an important statement. I think it will end up where Mr. Toll has suggested, namely, that there was an early commitment to the Canadians, the extent of which was not definitely determined until we got into the negotiations over the stretchout. At that time there was a solution to an earlier commitment that had no connection whatever with the stretchout.

Mr. WELLER. I should like to clarify one point that might partially answer Mr. Ramey's question.

With regard to the domestic industry, the reductions were 400 tons for fiscal year 1961, 400 tons for fiscal year 1962, and 200 tons for fiscal year 1963.

Mr. RAMEY. And there were no corresponding increases for 1964, 1965, 1966?

Mr. WELLER. No, sir; there were not on this projection.

Chairman ANDERSON. All right, we will inquire.

Mr. WELLER. As you know, the Uranium Institute, through testimony in these hearings for the past 3 years, has urged the establishment of an Atomic Industry Evaluation Council which could assemble experts of Government and industry from both the utilization and supply segments that could periodically evaluate and accurately report the significant information which would be of great assistance to the industry in plotting its future. We respectfully submit that the justification for such a council is more apparent today than ever before, and we again strongly urge the establishment of such a group.

Mr. Chairman, on this point we have argued this point many times with Commission officials and they have referred in the past to the fact that there existed a Raw Materials Advisory Committee in the Commission. We challenged this statement by asking, when and on what dates did this committee meet and when did they really consider these problems.

We find that the Raw Materials Advisory Committee had not met for 2 years prior to the time this question was asked. That question was asked April 11, 1958. Shortly thereafter the Raw Materials Advisory Committee was dissolved. There is no group at the present time, that is qualified at an official level, that pierces the administrative curtain of the Atomic Energy Commission that is able to review the program from an objective viewpoint.

We should like to suggest some of the informational aids that are immediately apparent, which such an organization could assemble and disseminate to the industry. First, it would be highly desirable to analyze the quantities of uranium which are currently being consumed by the various uses for uranium exclusive of atomic warheads. These uses should include uranium consumed in power reactors, research reactors, heat reactors, radioisotope production, military reactors, and chemical and research uses. Second, current information should be maintained with regard to spent nuclear fuels which are being sent to

hot storage and to reprocessing plants and the resultant production of radioisotopes and fissionable material from such operations. Third, a continuing analysis should be maintained for the total megawatt capacity of various types of nuclear powerplants, and of the ratio of consumption of uranium in its various forms to the kilowatt-hours produced, classified against such plant types.

Mr. RAMEY. I think figures on the first item are released, are they not, on uranium for civilian uses?

Mr. WELLER. I have never seen such projections. I know some very qualified groups that have sought to get a percentage of uranium consumed for peaceful uses or military versus monmilitary uses, and they have been unable to secure these. I did notice in this morning's Chicago Sun a figure that 95 percent of uranium was going to military uses, but I do not know how qualified that statement was.

Representative HOLIFIELD. If you had the total tonnage figure and you had the total civilian use, would it not be very easy for other countries to subtract the total civilian use from the total amount and arrive at the amount used for military use?

Mr. WELLER. I would like to ask what difference that makes. Our procurement so far exceeds all other countries that it doesn't seem to me to make much difference whether we have material for X number of warheads or X-plus-10-percent number of warheads.

Representative HOLIFIELD. Of course, we are not talking about procurement from other countries. We are talking about procurement versus production in the Soviet Union, which is a completely different comparison. In other words, we do not know what the production is there, but if they can arrive at exactly the amount of production that is going into military warheads here, I would assume that it would be interesting to them. There certainly would be no corresponding information obtained from them.

Mr. WELLER. Mr. Holifield, we have the list of all civilian and military reactors. We know their power ratings. We can make calculations as to the approximate uranium consumption from these. Anyone that wants to figure this from the standpoint of supplying information to a hostile nation can make a fairly good estimate.

Representative HOSMER. If you can make a fairly good estimate, that is suitable for your purpose; is it not?

Your do not have to know it down to the last pound and ounce.

Mr. WELLER. Again I just ask the question, Why should we not know?

Representative HOSMER. There are a lot of things that the Government could run around and collect and put out by way of useless bits of information; but why should it? Why should it take the taxpayer's money to do it? It would have to establish a bureaucracy to do it.

Mr. WELLER. The Bureau of Mines provides reports on consumption of other minerals which is extremely helpful to industry management. No Government agency does this for uranium.

Chairman ANDERSON. There is a little difference between the use of copper, lead, zinc, coal, and so forth, and the situation in uranium. It is, after all, a mineral that has only one purchaser at the present time, and these things are watched pretty carefully. Some time ago we had the problem that someone wanted to know exactly how much had been put into the peaceful uses of atomic energy. I have never

been able to get that figure jarred loose. The main reason is that if you knew exactly how much had been put in the peaceful uses and knew what the total appropriations had been, which we do know, you could automatically extrapolate and say so much is going into wartime uses and then you might be able to construct some figures on the stockpile of bombs, figures which thus far are pretty heavily classified.

I would like to have a lot of other information. As Mr. Hosmer pointed out, it may not serve any useful purpose. So I am perfectly satisfied to let it stay as it is without any publication of the amount put in peaceful uses. I think the same thing may apply to this. I don't know why they don't want to give it out. Somebody must have thought of a pretty good reason. All we can do is sort of suggest to them that maybe they can give this out someday, and maybe they will decide that there is a reason for giving it out.

Mr. WELLER. Mr. Chairman, in the context of all of this discussion, I should like to again read Chairman McCone's statement made in his testimony before this hearing on fuel supply, paragraph 192:

> The Commission receipts of uranium concentrates from all sources under its various domestic and foreign arrangements as projected over the next 3 years exceeds the Nation's estimated requirements to meet its weapons and power programs. The Commission has continued its efforts to bring supplies closer to balance with requirements by arranging for deferred delivery of domestic and Canadian concentrates.

We have established here that the industry is unable to gather any accurate understanding of what its demands are. It seems to us under such a circumstance the industry should hardly be the one to bear the brunt of changes of requirements which it does not understand.

Representative HOSMER. Wasn't this industry formed with the ground rules pretty well established as to who was going to buy and the known situation was fairly arbitrary. That is one of the things you people accepted when you got into this.

Mr. WELLER. We have this chart, Mr. Hosmer, which says, "Uranium Deliveries and Commitments." It was delivered to the industry by a formal address by an official of the Atomic Energy Commission in April 1959.

Representative HOSMER. My point was this: In addition to the other risks that an entrepreneur takes in the ordinary business, in the uranium business you assume additional risks, and accent additional conditions that are unique because of the nature of the beast, and of the nature of the market.

Your people know that when they go into this business. They accept these things. They don't have to go into the business. They have a choice. They could go into something else. Yet they have come into it. I think although they can complain to improve conditions, they cannot be too unhappy if changes are not made, because they did actually accept these conditions when they started in this business.

Is that a fair statement or is it radically unfair?

Mr. WELLER. Mr. Hosmer, I can refer you to many statements and I would be glad to include them in the record. I have put them in past testimony, of expressions of the U.S. Government as to how

critical it was to secure uranium and of the tremendous number and variety of inducements which the Government set up to encourage miners to get into the business of producing uranium. These inducements were widespead. There were some companies that came into the business and did some exploration work and made a study of what the Government assurances were and they decided "this doesn't look too good to us and we are going to withdraw for the time being."

There were other companies that chose to follow quite a different course. But those companies followed that course because they felt that the assurances were there. They had no means of knowing otherwise.

Representative HOSMER. You distinguish the uranium rush in the 1940's and 1950's from the gold rush of the earlier times and the attitude of the people engaged therein?

Mr. WELLER. I think that the conditions under which the uranium market was established by the United States were unprecedented. It was a tremendously important matter to the security of the United States that we establish these reserves. I think that the U.S. Government set up incentives and the industry reacted.

Representative HOSMER. I think we could argue this matter for a long time. I do want to say, Mr. Weller, you are doing a very fine job for your people. I think they should be proud of you.

Mr. WELLER. Thank you, sir.

Representative HOLIFIELD. This is very thoughtful and complete statement you are making, Mr. Weller. I confess that you have excited my curiosity in some areas. I respectfully request, Mr. Chairman, that the staff look at this statement and explore some of the problems that have been brought to our attention.

Chairman ANDERSON. We will do that.

Mr. WELLER. To continue, regular assessments should be made of the progress in the development of various breeder reactor concepts, and as these reactors approach economic feasibility, evaluation of their application in the economy, and the revised ratios of uranium consumed to kilowatt-hours produced, incorporated in any projections for estimated future demands for uranium.

We submit, Mr. Chairman, that through such a program the general understanding of the developments in atomic energy could be properly evaluated by the industry, and a genuine "confidence in the future market for uranium" could be developed in its proper proportion.

URANIUM RESERVES AND CONSERVATION NEEDS

In past years, uranium ore reserves have made substantial gains, increasing as much as 300 percent in 1 year's time. The July 1, 1959, AEC report indicated 88.9 million tons of uranium ore containing 0.28 percent U_3O_8 had been refined in the United States. At year end, as indicated on page 56 of the annual report, AEC estimates our domestic ore reserves at 86 million tons of 0.28-percent grade ore. For the first time in the history of the uranium industry, these figures suggest that our ore reserve gains were more than offset by our ore production—in the past 6 months our production was 3.5 million tons,

our new discoveries were 600,000 tons, resulting in a net loss of 2.9 million tons in the reserves remaining in the ground.

This condition again reflects a serious dampening of the enthusiasm which has been so characteristic of the industry's early operations and which resulted in such a tremendous growth of reserves here in the United States. I assure you our uranium reserve potentialities are greater than ever before—it is only the hunting spirit that is lacking.

There is another aspect which influenced our present ore reserve figures. The Atomic Energy Commission makes its ore estimates on the basis of ore reserves which can be economically produced for any given district. The more costly a ton of ore is to produce, the higher grade must be its uranium content to justify a classification as ore. Inflationary pressures on the domestic industry has therefore necessitated the raising of the average grade of ore reserves which qualify for recognition in the Atomic Energy Commission studies. At the time our present program was conceived, it was anticipated that 0.10 percent ore would be commercial in most districts of the industry. Today it is an unusual producer that can market uranium ore much under 0.20 percent grade unless he is an operator of his own mill.

Under these market conditions, thousands of tons of uranium ore which is now considered to be submarginal, but which often would assay 0.15 percent U_3O_8 or better is lost on the mine dump or left on the stope walls of a caved mine.

We note on page 5 of part IV of the Atomic Energy Commission's new program entitled "Civilian Power Reactor Program" that paragraph 11–b contains the following words:

> * * * the ultimate importance of conservation of nuclear fuels indicates a long range program to develop the breeding potential inherent in both uranium 238—plutonium and the thorium-uranium 235 fuel cycle.

The words "ultimate importance" in the above statement concerns our sensitivities. There are many experts in the atomic energy field who considered that uranium reserves, as presented by the Atomic Energy Commission are finite figures. These observers refer to the possibility of having ultimately to resort to the use of low-grade uraniferous shales which could be produced at a cost of $30 to $50 per ton of U_3O_8.

It is, therefore, important to emphasize, Mr. Chairman, the changes that could be reflected in our domestic reserves in the conditions which the enjoyed by the Canadian industry were extended to the uranium miners of the United States. At a price of $11.02 per pound of U_3O_8 now being paid on an average in the Canadian industry, the average grade of commercial ore in the United States could be dropped from its present 0.28 to below 0.20, and we submit that the tonnage of such reserves could be increased greatly.

It is, therefore, perhaps time for us to review the present price schedules of the domestic industry, and to consider the violation of good conservation concepts which are now being necessitated in the mine operations as we know them today. We may well regret, a few decades from now, the shortsightedness of our present program that prevented the mining of 0.15 to 0.20 percent grade ore in many of our underground operations.

RADIATION—FACT OR PHANTOM

It would be difficult to assess the deleterious effect which has been experienced by the uranium industry because of the widespread concern now being generated over the low-level radiation associated with the production of uranium. There are few new facts which have been developed in the industry in recent years beyond those which we have known all through the course of the entire development of the industry. Yet, because of an apparent competition for jurisdiction over the inspection and patrol powers of Federal agencies, the industry has been the topic of widespread newspaper notice and communities in the West have become unjustifiably concerned in this problem.

It is most important that we emphasize that the industry wishes to cooperate with every constructive program intended to promote the health of its employees and to safeguard the healthy environment that typifies every western community. We do, however, protest Federal agencies and newspaper writers sensationalizing this problem beyond all proper proportion.

It is interesting to note at a recent meeting sponsored by the Public Health Service and the departments of public health of several of the Western States at Phoenix, Ariz., at which river pollution problems stemming from the uranium industry's operations were to be considered, no uranium companies were invited until it was learned through one of the State agencies by a uranium company that the meeting was being held. As a result, thereof, two of the four companies with operations in the State were invited to attend the meeting.

Mr. Chairman, I cannot testify before this committee as an expert on the problems of radiation in the uranium industry. A very interesting article dealing with the radiation problems as well as other aspects of the uranium industry appears in the current issue of the American Mining Congress Journal, and I should like to submit a copy of this article by Mr. Mastrovich for the record.

(The material referred to follows:)

[Reprinted from American Mining Congress Journal, February 1960]

RADIATION DEVELOPMENTS

During 1959, the uranium industry took increasing measures to guard against radiation hazards from three general sources:

(1) Excessive concentrations of radon and its daughter products in the air of uranium mines.

(2) Control of excessive quantities of airborne uranium dust in milling operations, and,

(3) Regulation of the level of radium and other contaminants in the discharge of liquid effluents from uranium mills to river or potable water systems.

Many operators found it desirable to establish working relationships with the State health agencies, the U.S. Bureau of Mines, the Atomic Energy Commission, and the U.S. Public Health Service in order to assure that they were adequately informed with regard to all regulations affecting their operations.

In uranium mining the problem of radon daughter concentration in the mine atmosphere received increasing interest. Simple field methods are available for measuring radon daughters and for estimating ventilation requirements. Dilution ventilation is the only control method which has been applied to date for controlling radon daughter concentration and the cost of providing adequate volumes of air can be a significant factor in the economics of the operation of a mine.

In the past year, the Commission intensified its efforts to enforce compliance with its standards for protection from radiation. (Title 10, pt. 20, of the Federal Register, Jan. 27, 1957.) The Commission publicly cited 11 mill operators for failure to comply with these standards. Apparently most of these citations were made because of the slow start made by these mill operators in establishing a radiation survey program. Also, the U.S. Public Health Service showed interest in radioactive mill effluents as possible sources of stream contamination and action was taken against one uranium mill operator for allegedly polluting an interstate river.

In the majority of the mills, the external gamma and beta radiation levels are too low to be of concern as possible sources of radiation injury. The principal problem is that of control of the concentration of airborne uranium dust. Sampling of airborne uranium and the determination of the uranium concentration in air is a relatively simple matter and easily within the capabilities of the laboratory facilities of the uranium mills. Control of the concentration of airborne uranium can be achieved by careful housekeeping and the use of conventional dust collection equipment in those operations which generate airborne dust.

Compliance with those provisions of the standards which regulate the quantities of radium that may be discharged in the liquid effluents from uranium mills is most difficult. The analysis of radium in mill effluents, at the acceptable levels, requires a procedure which is expensive and which may be subject to appreciable errors. Additional research on the analytical methods is needed before the mills can accurately estimate the quantity of radium being discharged in their effluents. Corrective measures are now in their early stages of development, and suggest costly and involved procedures in their application.

The currently enforced Standards for Protection Against Radiation (pt. 20) are based on recommendations made by the National Committee on Radiation Protection published in Handbook 52 of the National Bureau of Standards dated March 20, 1953. On June 5, 1959, the National Bureau of Standards issued Handbook 69 which supersedes Handbook 52 and contains values which reflect the current thinking of the NCRP. The Commission has not revised its part 20 standards to conform with Handbook 69.

During 1959, the Federal Radiaton Council was created. This new agency is directed by officials of affected Federal agencies, and is expected to coordinate the work of these agencies. In addition, the Council will aid in preparing States to take over a part of the burden in regulating and controlling radiation hazards.

It is interesting to note that in hearings held to consider legislation establishing the Council, Dr. Lauritson Taylor, Chief of the Atomic Radiation Physics Division of the National Bureau of Standards, stated that the present standards, recommended by NCRP are based on the absence of observable effects on the human body. This, he added, is a "negative approach" of the problem, but he submitted that there is "no other way to do it."

Dr. Russell H. Morgan, Chairman of the Advisory Committee on Radiation of the U.S. Public Health Service, stated that the maximum permissible concentration levels, as provided in present radiation standards, are meaningless and "based on something other than scientific facts."

The public citations experienced by the industry during 1959 are symptomatic of the urgency felt by the appropriate authorities to establish and maintain rigid control on radiation hazards in the industry. The adverse publicity caused by those citations was unfortunate, and perhaps unwarranted in view of the primitive state of our knowledge of this hazard. The years immediately ahead should see a closer coordination of all private and public groups to effect the required corrections and to reestablish a more positive impression in the eyes of the public.

Mr. WELLER. Mr. Chairman, the Uranium Institute is deeply obliged to Dr. Geno Saccomanno, pathologist at St. Mary's Hospital at Grand Junction, Colo., who is a member of a group of distinguished research physicians investigating the occurrence of occupational diseases among uranium miners and employees of mills. The studies of this group, which is operating under a grant of the National Cancer

Institute and the Memorial Aid Fund, are drawn from pathological experience of this hospital serving the oldest uranium district in the Nation. The following report is contained in the letter as impressions drawn by the study at the present time.

1. There does not seem to be any specific occupational diseases associated with this industry in the material accumulated to date.

2. Cases of cancer of the lung or bones do not appear to be any more common with this occupation than in the average population, and that the cases with carcinoma of the lung in miners have, with no exception, been very heavy cigarette smokers, and the cause of the malady probably was due to this habit.

Mr. Chairman, I should like, at this point, to insert the entire letter in the record of my testimony.

(The letter referred to follows:)

ST. MARY'S HOSPITAL,
Grand Junction, Colo., February 17, 1960.

MR. GORDON A. WELLER,
Executive Vice President, Uranium Institute of America,
Grand Junction, Colo.

DEAR GORDON: Your inquiry relative to our research program is most welcome, and I shall summarize it as briefly as possible.

The U.S. Public Health Service has developed much concern about the possible hazards from radiation sustained by uranium miners and millworkers in your industry. Much of this concern, of course, is the result of the findings in certain mines in Europe in the early part of this century. It seemed to us that a study should be done in this field, and this study should be based on findings of miners and millworkers—if possible on live miners, and finally on deceased miners—autopsies. A team of research workers was selected in May 1959 and a grant was received from the National Cancer Institute, and the Memorial Aid Fund to cover the costs. The team of researchers is as follows:

1. Geno Saccomanno, M.D., pathologist, St. Mary's Hospital, Grand Junction, Colo.
2. Richard Saunders, M.D., pathologist, St. Mary's Hospital, Grand Junction, Colo.
3. Stuart Black, Ph. D., biophysicist, St. Mary's Hospital, Grand Junction, Colo.
4. Lynn James, M.D., internist, St. Mary's Hospital, Grand Junction, Colo.
5. Oscar Auerbach, M.D., pathologist, V.A. Hospital, East Orange, N.J.
6. Marvin Kuschner, M.D., pathologist, Bellevue Hospital, New York City.

The objectives of this study are as follows:

1. To do physical examinations including X-rays, blood studies and urine polonium and lead studies on live miners to determine their present status, including, if possible, the amount of radiation sustained to the present.

2. To do autopsies on miners and to do serial section studies of lungs and polonium and lead studies on tissues.

3. To do case histories on these cases and coordinate all findings to determine if there is any occupational disease or hazard associated with uranium mining and milling.

Impressions to date are as follows:

1. There does not seem to be any specific occupational diseases associated with this industry in the material accumulated to date.

2. Cases of cancer of the lung or bones do not appear to be any more common with this occupation than in the average population, and that the cases with carcinoma of the lung in miners have, with no exception, been very heavy cigarette smokers, and the cause of this malady probably was due to this habit.

This study, of course, is one that will have to proceed for probably many years in order to accumulate a sufficient number of cases to do an adequate statistical study.

Very sincerely yours,

ST. MARY'S RESEARCH GROUP,
By GENO SACCOMANNO, M.D.

FOREIGN URANIUM COMMITMENTS

Mr. WELLER. Over the next several years, the uranium industry in the United States will be competing with other uranium-producing countries for world nuclear fuel markets. In doing so, our industry, will be competing with the sources beyond our borders from whom we have been buying substantial quantities of uranium. In appraising our preparedness to successfully engage in such commerce, we find that our competing world sources are now receiving prices ranging from 15 to 60 percent higher than prices set by the Commission for uranium production in this country. This condition has forced domestic producers to take strong positions against the producers in these countries for whom we otherwise feel the most friendly tie. Our competitors are being subsidized through taxes we pay.

Mr. Chairman, in the annual report of the AEC on page 61, the Commission states that it "amended its contracts with Eldorado to procure additional amounts of U_3O_8 in concentrates prior to March 31, 1962, from certain Canadian producers." The contract amendments involved the following amounts from the producers listed below:

Producer	Pounds U_3O_8	Price per pound U_3O_8	Value of contract
	Thousands		*Thousands*
Gunnar Mines, Ltd	4,500	[1] $8.75	$37,400
Pronto Uranium Mines, Ltd	1,508	8.00	12,064
Algom Uranium Mines, Ltd	2,456	8.00	19,648
Bicroft Uranium Mines, Ltd	260	8.00	2,080
Total commitment extension	8,724		71,192

[1] Canadian dollars.

Mr. WELLER. It is interesting to note that Congress was first publicly informed of these contract amendments by testimony from the Uranium Institute of America before the Joint Economic Committee last October. At that time, we included the quotation from a representative of the AEC which explained the Canadian contract extensions as follows:

> I should like to emphasize that execution of the particular contracts involved was in the nature of a formal and detailed reflection of long-established understandings between the United States Commission and Canada. For your information, most of the negotiations with respect to the pricing arrangements for these extensions had been completed about a year ago.

Mr. Chairman, a formal procurement program extension was offered to the domestic industry clear back on May 24, 1956, and then was seriously modified and reduced on November 24, 1958, several months before the Commission felt a moral obligation to formalize "understandings" to the Dominion of Canada, which had never been made public until some time after their final execution.

We are also concerned that the Commission found it necessary to negotiate its extension with Gunnar Mines, Ltd., at a price of $8.75 Canadian (US$8.31) per pound of U_3O_8. Yet it can be authoritatively established that Gunnar's operating costs are probably one of the lowest of any primary uranium producing operation in the world.

Additional facts concerning the economics of this operation can be secured from the current issue (February 1960) of Engineering and

Mining Journal, page 110. This same source advises us that during 1959, Rayrock Mines found it necessary to close its operations with two-thirds of its contract with Eldorado yet unfilled. We are advised that Stanleigh, Stanrock, Can-Met, and Canadian Dyno have also encountered difficulties and found it necessary to make serious adjustments in their operations. This report tells us that Laredo has very little ore with two-thirds of its contract yet unfilled. Then we are advised that any Canadian mine may sell its contract to another producer, and the Wall Street Journal has since carried an item that Rayrock Mines sold its contract to Gunnar for a reported $5 million.

Mr. Chairman, I submit that this experience makes it absolutely obvious and mandatory that every vestige of secrecy must now be stripped from the raw materials program of the Atomic Energy Commission, and that the history of all contracts and obligations and the terms of those contracts be fully documented for public inspection. The type of commitment juggling which is suggested by these reports would never be permitted in the domestic industry and they should not be permitted wherever the American taxpayer's money is involved.

(Subsequent correspondence regarding Mr. Weller's testimony on "Foreign Uranium Commitments" follows:)

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
Washington, D.C., February 25, 1960.

Gen. A. R. LUEDECKE,
General Manager,
U.S. Atomic Energy Commission,
Washington, D.C.

DEAR GENERAL LEUDECKE: It is requested that AEC comment on the testimony of Gordon A. Weller before the Joint Committee on February 19, 1959, concerning "Foreign Uranium Commitments," at pages 13–14 of his statement, including the following:

(a) The reasons for stamping the AEC January 15, 1959, letter and the February 16, 1959, testimony "Official Use Only"; and

(b) The date the Commission stipulated a minimum of 68,000 tons of deliveries from Canada during the July 1, 1955–March 31, 1962, period, and the reasons for the Commission stipulating such a minimum.

It is requested that the Commission furnish these comments to the Joint Committee by March 15, 1960.

Sincerely yours,

JAMES T. RAMEY, *Executive Director.*

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., March 12, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy, Congress of the United States.

DEAR MR. RAMEY: As requested in your letter of February 25, 1960, we are pleased to comment on pages 13 and 14 of the statement given by Mr. Weller before the Joint Committee on February 19, 1960, concerning our Canadian procurement program. We will also make specific comment on the reasons for marking our letter of January 15, 1959, dealing with the above subject and our testimony of February 16, 1959, "Official Use Only." In addition, we will discuss the establishment of the minimum figure of 68,000 tons U_3O_8 for Canadian deliveries in the period July 1, 1955, to March 31, 1962.

Mr. Weller's statement appears critical of foreign uranium procurement, particularly the Canadian contracts. Maintenance of the U.S. world leadership has been in large part due to our military strength and atomic superiority. The availability of foreign uranium and the willingness of the foreign countries to develop production on a crash basis has contributed materially to our present position. During the period of uranium shortage negotiations for both domestic

and foreign uranium were carried out under conditions of extreme urgency. Nevertheless, the terms of the contracts for this uranium are considered reasonable. We will, of course, honor the foreign contracts in the same way we do contracts with domestic producers.

In 1947 when the U.S. Atomic Energy Commission was established, there was practically no domestic uranium production and no significant quantities of known ore reserves. This country was dependent almost entirely upon foreign uranium for its atomic weapons program. Additional uranium from any available source was needed to meet the urgent requirements. This called for a worldwide uranium search. The major emphasis, however, always has been upon the development of an adequate domestic supply. Although at the start of the program domestic prospects seemed relatively poor, and our production was slow in developing, today the United States is the world's leading uranium producer. Our foreign contracts were all negotiated during the period of uranium shortage.

Mr. Weller has pointed out that the prices being paid by the Commission for foreign uranium production exceed those being paid for domestic production. An important factor in connection with the higher prices negotiated for foreign uranium is the lower grade of the ores. On an average, about 10 tons of South African ore must be mined and milled to produce 5 pounds of uranium oxide in concentrate. The same number of pounds of oxide is obtained by mining and milling 2½ tons of Bancroft and Blind River ores which furnish the bulk of the Canadian production. Only 1 ton of average domestic ore is required to produce 5 pounds of oxide.

It is interesting to note, however, that it is only during the last 3 fiscal years that the average price paid for domestic uranium was lower than the average price paid for foreign uranium. The lower domestic price in these years is the result of new contracts and contract amendments that reflect lower costs due to improved metallurgical processes and increased recoveries, more efficient milling operations, and larger mills. The prices paid to U.S. producers for ore have remained unchanged, as established by Circular 5, revised, in March 1951. We would not, of course, be buying foreign uranium today at the higher prices if it were not for the fact that current deliveries are being made under contracts negotiated some time ago when domestic production was insufficient to meet our requirements.

The statement refers also to page 61 of the AEC's Annual Report for 1959 concerning contracts with Eldorado Mining & Refining Limited for procurement of additional amounts of U_3O_8 in concentrates prior to March 31, 1962, from certain Canadian producers. With regard to these contract extensions Mr. Weller makes the following statement:

"Mr. Chairman, a formal procurement program extension was offered to the domestic industry clear back on May 24, 1956, and then was seriously modified and reduced on November 24, 1958, several months before the Commisison felt a moral obligation to formalize 'understandings' to the Dominion of Canada, which had never been made public until sometime after their final execution."

The facts are these: In the spring of 1956 Canada and the United Kingdom approached AEC with the request for release to the United Kingdom of 5,500 tons of U_3O_8 then under contract to us for delivery to the United Kingdom between July 1, 1958, and March 31, 1962. At that time domestic ore reserves were sufficient only to carry the industry for a few years at the contemplated rate of production, a situation leading to the Commission's announcement of May 24 establishing a market for uranium concentrates in the period March 31, 1962–December 31, 1966. In view of the domestic reserve situation the Commission could consider the Canadian-United Kingdom request only if it were able to be assured of full delivery of at least 68,000 tons of the U_3O_8 then under contract for delivery prior to March 31, 1962, after giving effect to the diversion to the United Kingdom. The Commission believed that this quantity of Canadian uranium was needed to support its programs.

In early May 1956 the Commission agreed to release from its Canadian contracts the 5,500 tons of uranium for sale by Canada to the United Kingdom, contingent on the understanding that Canada would be able to deliver to AEC a minimum of 68,000 tons in the period July 1, 1955, to March 31, 1962. Under this arrangement our maximum obligation was to purchase 71,000 tons U_3O_8. This excluded deliveries in the period March 31, 1962–March 31, 1963.

Information on the Commission's action was furnished to the Joint Committee in our letter of May 10, 1956. Eldorado Mining & Refining Limited, the Canadian

Government corporation with which the Commission held contracts, was formally advised on May 11, 1956, of the Commission's contingent decision to release uranium to the United Kingdom. Its acceptance was dated May 30, 1956.

In addition to the 5,500 tons U_3O_8 which the United Kingdom undertook to purchase prior to March 31, 1962, the AEC in April 1957 agreed to further release to the United Kingdom from its contracts a quantity of 5,000 tons U_3O_8 to be delivered in the 1-year period March 31, 1962–63. Such a release was still contingent on the delivery of the minimum quantity of 68,000 tons.

By midsummer of 1957 it became apparent that domestic reserves could be expected to continue to increase rapidly, and in August 1957 the Commission relieved Eldorado Mining & Refining Limited, acting for the Canadian Government, of its obligation to produce and deliver the minimum quantity, it being our desire to limit our obligations to those already covered by contracts or letters of intent. We were subsequently advised that Canada, prior to receipt of our notice of release had, pursuant to AEC's undertaking to purchase a minimum of 68,000 tons, made commitments to certain producers to extend contracts which would expire before March 31, 1962. The Canadians informed us they had done this since, in order to make a firm contract for the quantity desired by the United Kingdom, Canada had had to assure itself it would be in a position to make the minimum total delivery to us. The extensions of the Algom, Pronto, and Bicroft contracts referred to in Mr. Weller's statement were the three contracts involved.

The extension of the Gunnar contract was the result of an expansion program negotiated in late 1955 and early 1956 and was covered by a letter of intent dated May 18, 1956, from the Commission to the Canadian Government. We believe that the price of $8.75 (Canadian) to be paid for the additional Gunnar production is reasonable. It was based on the cost of expanding both mining and milling facilities as well as the cost of production, taking into consideration the increased cost expected from transition from open pit to underground mining. In the case of all four contracts the final pricing arrangement was subject to a certain degree to negotiation. The delay in formalizing the contract amendments was due in large measure to the price negotiations and to the fact that delivery of the additional quantity would not commence until sometime in 1961.

The statement also criticizes some aspects of the arrangement which has been made with Canada involving the deferral of some of the deliveries which otherwise would have come to the AEC over the next 2 or 3 years, a period in which total receipts are in excess of requirements. The Canadian Government had been advised that the Commission would not be in a position to exercise its options to purchase additional Canadian uranium concentrates in the post-1962 period. By contrast, domestic producers were assured of a continuing market through 1966. The AEC was interested in reducing its total uranium deliveries in fiscal years 1960, 1961, and 1962 and the stretchout arrangement announced November 6, 1959, also offered an opportunity to lessen the impact on a friendly country which otherwise would result from almost complete cessation of uranium production on the expiration of the AEC contracts.

A prerequiiste to such an arrangement which would permit reduction in current deliveries and at the same time provide for the continued operation of a segment of the Canadian uranium industry was consolidation of the contracts between Eldorado and the Commisison into a single contract involving no change in the total quantity to be delivered or total cost. Within the framework of this single contract the Canadian Government was free to allow consolidation of operations on any basis which would promote the foregoing objectives. We believe that the stretchout as agreed upon was in the interests of both the United States and the Canadian Governments.

Referring to the reasons for stamping the AEC letter of January 15, 1959, and the February 16, 1959, testimony "Official Use Only," we have the following comments. The January letter, among other things, referred to the execution of contracts which were proposed in accordance with our obligations. Neither the contracts between the Canadian Government and the producers nor the corresponding AEC–Eldorado contracts had been executed and we considered that it would be inappropriate for this information to be released prematurely. Furthermore, the letter contains information on other matters which we are not at liberty to publicly release at this time.

The February 16 testimony included much information which we believed the Joint Committee should have regarding discussions in progress as well as information on matters which we are not free to release without the consent of the foreign countries concerned. It would have been undesirable and possibly

prejudicial to our negotiations to release the information on the discussions which was given the Joint Committee. You will recall that an unclassified statement was prepared and released by the Joint Committee, but we are not yet free to release other portions of the testimony. At that time the Canadian extensions had not been executed in Canada nor in the United States and for the same reasons given above this information was not included in the unclassified version.

Sincerely yours,

A. R. LUEDECKE, *General Manager.*

CIVILIAN POWER REACTOR PROGRAM

Mr. WELLER. Finally, but of great importance, we wish to present the views of the Uranium Institute on the report of the civilian power reactor program of the Atomic Energy Commission.

First it is obvious that the presently projected program cannot be accomplished in time to fulfill a demand for uranium equivalent to that now being produced under the Government procurement program. It is difficult for us to understand why it should take until 1968 to achieve atomic powerplant concepts capable of producing 7-mill power when the Commission itself submits that several manufacturers in the United States are now prepared to construct such plants on a fixed-price basis, with fuel guarantees, that will produce power at this rate.

Secondly, we submit that the highly industrialized nations of Europe are not necessarily the only potential area for the establishment of pioneering atomic powerplants under our foreign assistance program. The deemphasis of the Euratom program should not be a detriment to our objectives in international atomic energy assistance and we should reread the very impressive and persuasive arguments of Dr. H. J. Bhabha, of India, and revamp our international assistance program so that it can be truly applied to the underdeveloped nations of the world.

Third, we see a marked deemphasis in the long-range program directed toward the ultimate reduction of costs of nuclear power. The hope of materially increasing economic benefits and of extending those benefits to the lower cost fuel areas in an important objective of our entire program. We urge the revitalization of programs directed toward this objective and the establishment of definite timetables and targets toward which to work.

Fourth, the potentialities of the U.S. industry and technology under the incentives of our free enterprise system can outrun the accomplishments of any other governmental system in the world. U.S. leadership in the technology of nuclear power for civilian use can be maintained if the present shackles with regard to patent policy are revised. It is entirely unrealistic to expect our Nation's industry to dedicate its best talent to the objectives of our atomic energy program when those companies cannot receive the patent benefits created in the performance of that work. If this right is denied them, the companies will direct the channels of such talent in the areas where such benefits will accrue.

If we adopt the urgency which was expressed by Chairman McCone before the Atomic Industrial Forum a few months ago in pressing for the truly commercial benefits that will accrue through atomic

energy, there need be no fear as to the rate of advancement that the U.S. industry can make in the field of atomic energy.

Fifth, we see breeder-type reactors as an important concept which should be developed in the long-range program for civilian power reactors. We urge that far greater emphasis be placed upon research in fuel cycles and chemical reprocessing, and on nuclear superheat as goals which, when accomplished, will bring far greater immediate benefit to the atomic energy program.

In conclusion, Mr. Chairman, in reviewing the problems of the uranium industry, we have sought to deal with those phases which are most directly concerned with the interests of this committee. There are many other phases of the industry's operations which must also be given careful study if we are to maintain a healthy environment for the people engaged in this business. Among these problems are (1) policy interpretations of the Internal Revenue Code dealing with tax depletion for the production of uranium concentrates; (2) policies of the Bureau of Land Management concerning uranium claims on lands under its jurisdiction; (3) newly proposed legislation including the proposed Resources and Conservation Act of 1960 and proposals for the establishment of a wilderness system. Some of our members have also expressed a decided interest in your bill S. 2878, Mr. Chairman, dealing with the adjustment of Indian and non-Indian land use in areas adjacent to the Navajo Indian Reservation in New Mexico.

In each of these cases, it is our hope that the Uranium Institute will be given the proper opportunity to be heard on these questions, so that we may more effectively present our case and avoid burdening this hearing with further testimony relating to the subjects.

We do submit that the problems relating to the operation of the uranium industry are manifold and that this testimony is therefore grossly inadequate. Our statement here has rather been intended to set some signposts that will suggest to you gentlemen the need for specially called hearings devoted to the problems of the raw materials program of the Atomic Energy Commission, whereby all of the facets of the domestic, Canadian and overseas procurement programs may be fully examined.

Thank you very much.

Chairman ANDERSON. Thank you, Mr. Weller.

We are adjourned until Tuesday afternoon at 2 o'clock.

(Whereupon, at 12:10 p.m. Friday, February 19, 1960, the committee was recessed, to reconvene at 2 p.m. Tuesday, February 23, 1960.)

DEVELOPMENT, GROWTH, AND STATE OF THE ATOMIC ENERGY INDUSTRY

TUESDAY, FEBRUARY 23, 1960

CONGRESS OF THE UNITED STATES
JOINT COMMITTEE ON ATOMIC ENERGY,
Washington, D.C.

The committee met, pursuant to recess, at 2 p.m., in room P–63, the Capitol, Senator Clinton P. Anderson (chairman of the Joint Committee) presiding.

Present: Senators Anderson, Gore, and Dworshak; Representatives Durham, Holifield, Price, Aspinall, Van Zandt, Hosmer, Bates, and Westland.

Also present: James T. Ramey, executive director; John T. Conway, assistant director; David R. Toll, staff counsel, and George F. Murphy, Jr., professional staff member.

Chairman ANDERSON. The committee will be in order.

This afternoon the Joint Committee is meeting to receive testimony from witnesses from industry on the development, growth, and state of the atomic energy industry.

Our first witness this afternoon is Dr. Chauncey Starr of Atomics International.

We are happy to have you with us again, Dr. Starr. Will you please proceed?

STATEMENT OF DR. CHAUNCEY STARR, GENERAL MANAGER, ATOMICS INTERNATIONAL DIVISION, AND VICE PRESIDENT, NORTH AMERICAN AVIATION, INC.

Dr. STARR. It is nice to see you all here again.

If I may proceed with my prepared statement, all of us in the atomic energy field have recognized for many years the necessity for establishing long-range planning. The past deliberations of this committee, the Atomic Energy Commission, its contractors, and many others, have indicated quite clearly the existence of a multiplicity of objectives which any realistic national program must satisfy.

At previous meetings of this committee, I have been privileged to comment on various of these objectives and their ramifications.

In my remarks today, I plan to cover certain aspects which I believe deserve additional attention and clarification because of their timeliness.

1. Uranium resources.

One of the basic considerations which has entered into long-range planning concerns the availability of uranium for a future nuclear power system. The assumption has sometimes been made that our

uranium resources are in such short supply as to make questionable the future contribution of atomic power, unless all potential resources are fully utilized through the use of nuclear breeders. This concern is expressed in the fifth program objective of the AEC's most recent civilian power reactor program.

In view of the fact that at the present state of breeder reactor technology, such reactors have excessively high power costs, the complete acceptance of this doctrine would alter the basis of our present national program, by diminishing the near-term incentive for the development and construction of nonbreeder atomic powerplants, and by leaving the long-term value of atomic power generally in doubt. It therefore is important to examine the resources situation in detail.

Unfortunately, most of the past studies of this subject have not considered the influence of ore costs on nuclear reactor performance. This has caused some misconceptions concerning the relationship between uranium ore resources and the future of atomic power.

Our organization has made a rather comprehensive study of this subject, and I would like to present to this committee a short summary of our findings.

First, it should be recognized that there is an enormous difference between proven uranium reserves and the probable resources which could be developed if the price of uranium ore were permitted to increase. The influence of economic incentive on developing reserves is of course well established by the fact that in the last decade our domestic uranium reserves have been increased almost 100 times under economic stimulus.

A study of the uranium resources in the United States, and in the world, indicates that these resources would again increase by the hundreds to thousands if the price of uranium ore is increased, as illustrated by the accompanying chart (chart 1).

We have plotted on this chart the availability of uranium in tons against the cost of the ore.

As you see, our present reserves are in this lower corner. We are somewhere in the range of $10 or less a pound of uranium oxide and we are in the area of reserves—just for the United States—of about a million tons.

If the price were to go up by a factor of 10 or go up by a factor of 100, the reserves move up into the billions of tons. This upper line represents reserves which are fairly definitely pinned down.

The lower line represents what the optimistic people in the mining industry think they can get.

The middle is probably the realistic area.

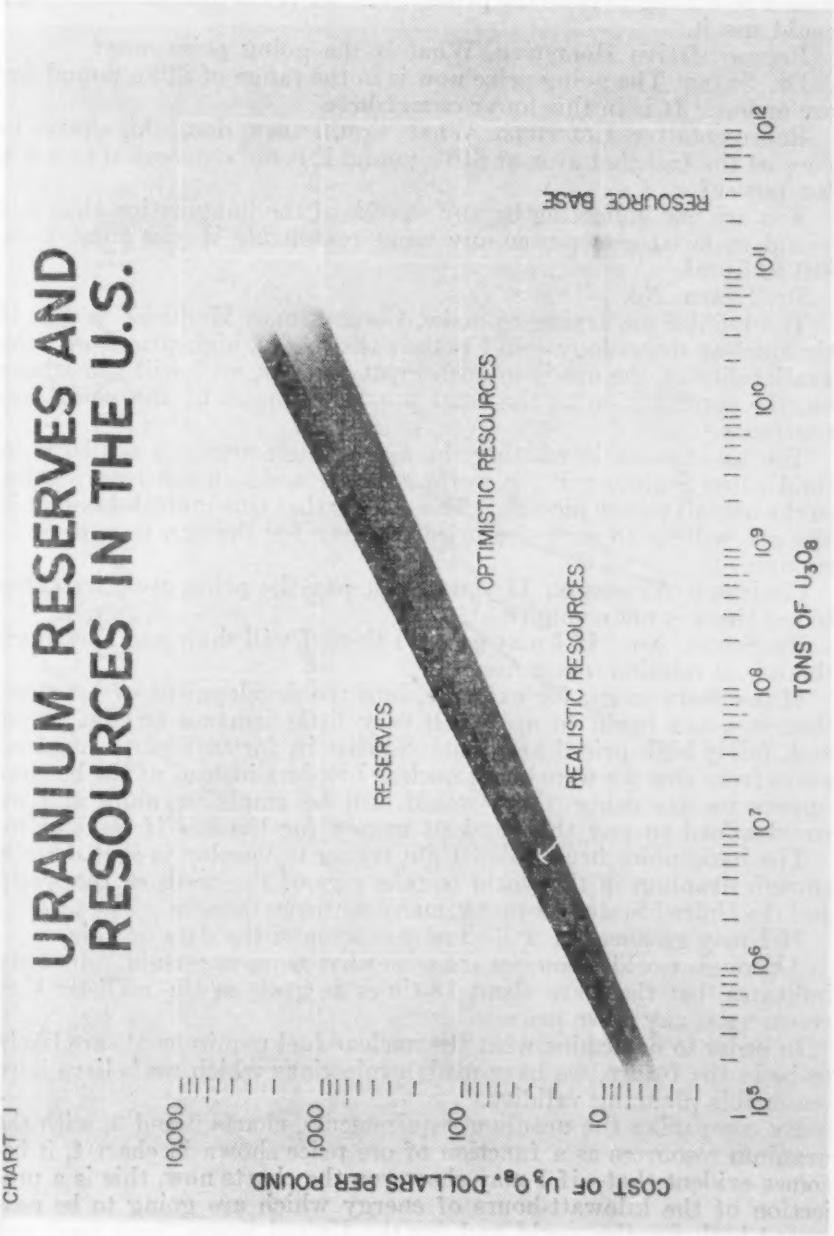
The general point here is that if you are willing to pay more for uranium, you can get in the range of hundreds to thousands of times the amount of ore which we now have as proven reserves.

Chairman ANDERSON. I could not tell by reading this just what it meant.

"Would increase by the hundreds to thousands." Does that mean increase ten times or would it increase a hundred times to a thousand times?

Dr. STARR. It would increase from a hundred times to a thousand times. Let me give a specific example.

CHART 1


URANIUM RESERVES AND RESOURCES IN THE U.S.
CHART I
COST OF U_3O_8, DOLLARS PER POUND
10,000
1,000
100
10
1
TONS OF U_3O_8
10^5
10^6
10^7
10^8
10^9
10^{10}
10^{11}
10^{12}
RESERVES
REALISTIC RESOURCES
OPTIMISTIC RESOURCES
RESOURCE BASE

52950—60——20

If we were willing to pay $100 a pound for the uranium oxide, we could probably get close to 100 million tons of ore as reserves in the United States as compared with the million that we have. As I will mention later on, there are conditions under which we would be willing to raise the price of the ore if the nuclear technology could use it.

Representative HOLIFIELD. What is the going price now?

Dr. STARR. The going price now is in the range of $10 a pound for ore or less. It is in this lower corner here.

Representative HOLIFIELD. What significance does this have in view of the fact that even at $10 a pound it is not economical to use it for power?

You are not indicating by any stretch of the imagination that this would make atomic power any more reasonable if you went from $10 to $100?

Dr. STARR. No.

The point I am trying to make, Congressman Holifield, is that if the nuclear technology could permit the use of high-priced ore, the availability of the ore is in such great amount, as I will show later on, the contribution to the total power resources of the world are enormous.

The basic point is whether there is enough uranium available in the United States or in the world to make a significant contribution to the overall power picture. The answer that this indicates is that if you are willing to raise the price you pay for the ore, then there is enough.

Chairman ANDERSON. If you do not pay the price, are you trying to say there is not enough?

Dr. STARR. No. If I may go on, I think I will show you how much there is in relation to our needs.

If one were to go, for example, into the development of breeders, then you can begin to use, with very little increase on the power cost, fairly high-priced uranium. So that if, for example, a hundred years from now we were using nuclear breeders instead of the burner-uppers we are using, there would still be ample uranium and we could afford to pay this kind of money for the ore if we had to.

The basic point here which I am trying to develop is that there is enough uranium in the world to take care of the needs of the world and the United States for many, many centuries to come.

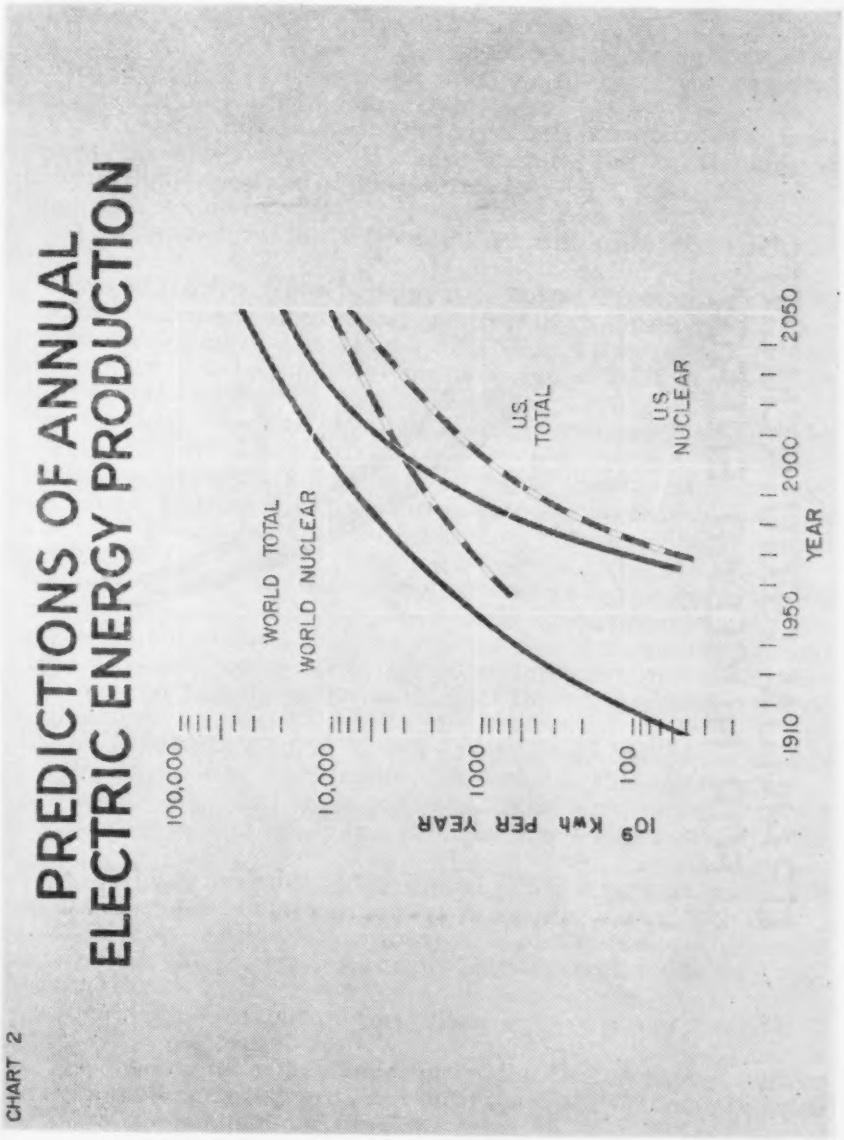
If I may go ahead, I will show you some of the data on this.

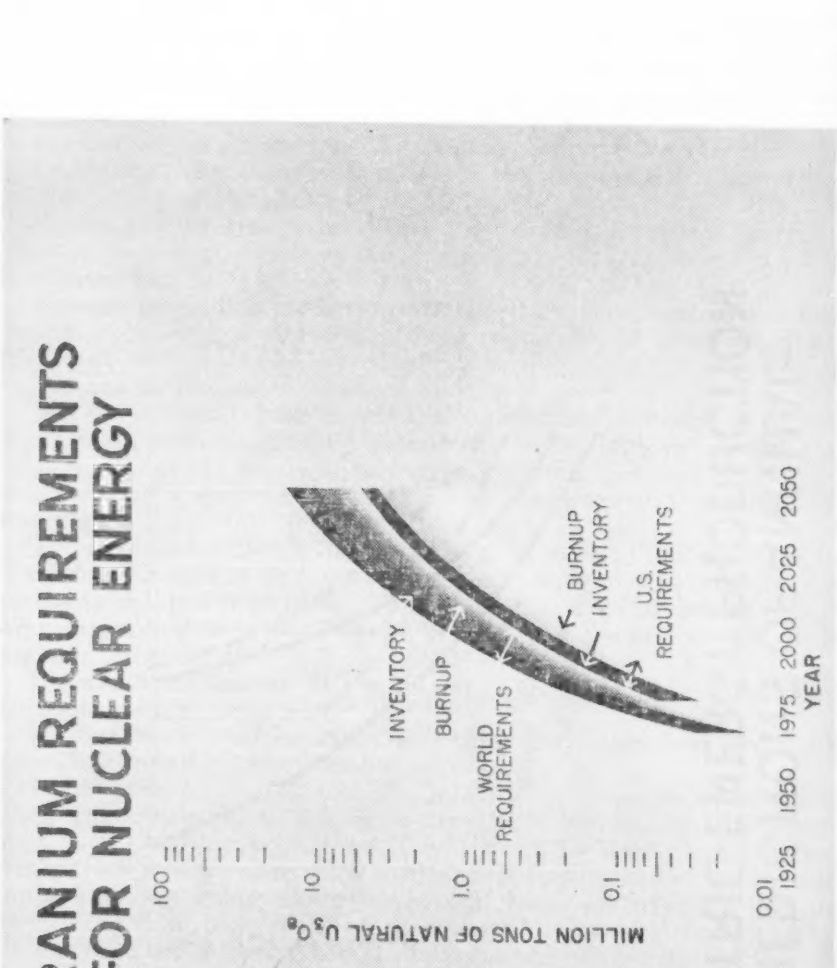
Although world resources are somewhat more uncertain, our study indicates that these are about 18 times as great as the realistic U.S. resources at any given price.

In order to determine what the nuclear fuel requirements are likely to be in the future, we have made projections which we believe have reasonable planning validity.

By comparing the uranium requirements, charts 2 and 3, with the uranium resources as a function of ore price shown in chart 1, it becomes evident that—if I may show you the charts now, this is a projection of the kilowatt-hours of energy which are going to be estimated both for the world and for the United States, both total and nuclear.

CHART 2


PREDICTIONS OF ANNUAL
ELECTRIC ENERGY PRODUCTION
CHART 2
WORLD TOTAL
WORLD NUCLEAR
U.S.
TOTAL
U.S.
NUCLEAR
100,000
10,000
1000
100
10^9 kWh PER YEAR
1910
1950
2000
2050
YEAR


URANIUM REQUIREMENTS
FOR NUCLEAR ENERGY
CHART 3
MILLION TONS OF NATURAL U_3O_8
100
10
1.0
0.1
0.01
1925
1950
1975
2000
2025
2050
YEAR
INVENTORY
BURNUP
WORLD REQUIREMENTS
BURNUP
INVENTORY
U.S. REQUIREMENTS

We have been bold enough to project this for a hundred years. These estimates are based upon trends which have actually been established for the past 100 years.

I believe I supplied to the staff of the Joint Committee a more detailed report showing the background of these data so that this could be gone into in greater detail (see appendix 11, p. 660).

Chairman ANDERSON. The heavy area is what?

Dr. STARR. That is the world's requirements and the light area the U.S. requirements. This is based upon a growth of the electrical energy both in the United States and the world.

I think for the purposes we want today, these are probably as good a projection as one can get. We have compiled the best thinking of the electrical industry and of other sources.

Chairman ANDERSON. Does that show that in a hundred years, 95 percent of energy in the United States will come from nuclear sources?

Dr. STARR. In the United States it is about 80 percent, in about a hundred years, of the electrical energy will be nuclear. We have to make some kind of assumption. We assume that nuclear power-plants are going to be successful and that on that basis, as the utility industry develops it will begin to use these.

We have also converted this into what the uranium is going to be used for.

I might point out that there are two things that the uranium goes into. One is inventory in the plants. This is quite a sizable amount.

The other goes to taking care of the amount of energy being burned up each year.

We have added these two up together and we have a curve for the U.S. requirements and for the world requirements. If you take the United States alone, you will see that these are the millions of tons of natural oxide which are going to be required in the year 2050. You are talking here something of the order of magnitude of 5 million tons.

If you look at this curve, this is uranium required if the energy goes this way. Now we compare this with the first curve which I showed you, which had to do with the availability versus price. I think the key point I am trying to make now I will summarize for you.

First, uranium available in the United States at present prices will support the projected nuclear industry beyond the year 2000.

2. If the same considerations are applied to the world requirements and resources, the present prices would satisfy word needs until well after the year 2000.

In other words, without raising prices, we have plenty available at the turn of the century.

3. The total uranium requirements of the United States' nuclear electrical power industry projected until the year 2050 could be made available if the uranium ore price was raised to about $23 per pound, with no imports required.

4. Total world requirements up to the year 2050 could be satisfied by an increase from the present $8 per pound to a price in the year 2050 of $9.50 per pound, if potentially available world resources are considered.

It is clear if we were to import any uranium at all, there would be very little increase of price in uranium to the year 2050 to supply all the projected needs.

Chairman ANDERSON. Doctor, would you help me in this. You have me a little confused on charts. I am trying to follow your third chart.

From 10 to 100 is almost the same space on the chart as from 1 to 10.

Dr. STARR. That is right, sir.

Chairman ANDERSON. I would think it would be nine times as much.

Dr. STARR. The chart is plotted in what is called a logarithmic projection. Everything runs by a factor of 10.

Chairman ANDERSON. I see that, because from 1 down to a tenth is the same distance as 10 to 100.

Dr. STARR. Yes, sir.

This is just a device for contracting the chart so that it doesn't go through the roof of the building.

Chairman ANDERSON. It gives you a wholly false picture, does it not?

Dr. STARR. I think one has to look at the numbers to get the feeling for it.

We are down here now. To put this chart on a linear base, that is on a straight line scale, we would be going way, way up with the paper. So this is a technique that we use for presenting the material in a condensed form.

I think your point is well taken, that these distances go up by a factor of 10 each time.

Representative HOLIFIELD. It is still true the way you have it as long as you take into consideration that it goes from one-tenth to 1, and from 1 to 10 and from 10 to 100.

Dr. STARR. Yes.

If we take this point which is 5 million here and come back here to 5 million right down here, we just have to go up to about $23 a pound for the ore to essentially take care of us for about a century.

Chairman ANDERSON. We have been having some trouble in the Finance Committee trying to show what has happened to our interest rates on the national debt. I think I know how to do it now.

Representative BATES. In order to get a perspective of the importance of the price structure here, I wonder if you could give us an idea of power cost at 15 mills.

What impact will the prices have on that 15 mills?

What are we talking about?

Dr. STARR. You are anticipating my testimony, but I will be happy to answer.

Representatives BATES. Let it go then.

Dr. STARR. I will answer it now.

This $23 a pound, instead of $8 a pound which we are paying now roughly, would affect the cost of power in our present type of reactors by one-half mill a kilowatt-hour as compared with the 7 to 8 or 10 mills a kilowatt-hour which the power actually costs now. So you are talking here about an effect of maybe 5 percent on the cost of power.

That is assuming that there is no technological improvement in the nuclear reactors themselves, and there is going to be more than a 5-percent improvement in their performance.

I think the real import of these numbers is that certainly for the next century there just is not a really serious problem as to where the uranium is going to come from if we were to have a growing nuclear power industry both in the United States and in the world. This is a very important point because it means that the atomic energy business is a worthwhile national effort.

Representative BATES. If the fast breeder is actually developed and works successfully, what then would be the impact?

Dr. STARR. It multiplies these resources by a huge amount. It means we could be taken care of for hundreds and hundreds of years.

Representative BATES. It cuts that differential to what fraction?

Dr. STARR. It depends on how well it goes. It would cut it to maybe a tenth of this differential.

I have some tables later on that show some of this. If I may perhaps, since I have already answered that point of how much does the power increase go on, this half a mill of kilowatt-hour, I might go to the next point, which is to show you how uranium resources compare with conventional resources (chart 4).

I will give you a number to compare with the numbers on this table. If you were to estimate the total amount of energy that we need for the electrical power of the United States to the year 2050—that is 90 years from now—it turns out to be in these units called Q, 3½ Q. A Q is a trillion B.t.u. It is just a convenient number.

The total energy requirement of the United States for electrical purposes is three and a half. You compare this with the availability of oil, gas, and coal, and uranium and we have two kinds of uranium usage, one in the present type of reactors and then the final one in the breeder reactors.

You will see that the reserves as now established—I might again indicate the difference between reserves and resources—reserves are things that are geologically proven out, resources are estimates made by geologists of what might be there, if you look for it.

If you take the reserves, the crude oil and gas make a very small contribution. The coal is obviously big enough. What we want is 3½ Q as compared to the 24 which is here.

Uranium in ordinary reactors is not sufficient if there is no increase in price. As I pointed out, there would have to be an increase to $23 a pound to make it sufficient. If you put it into breeders, it is amply sufficient and has as much value as the coal. These are the reserves. These are the things we already have staked out. The mining industry has these staked out.

If I go to resources, which might be there if you look for it, you will find that oil and gas compare rather favorably with this 3½ Q. The two together could actually take care of it. The coal is again in ample supply. But even the uranium in present reactors is thousands of times greater in terms of what would be available than the requirement, the 3½ Q.

If you put it into breeders, then you go up again by a factor of a hundred or so.

CHART 4

RESERVES AND RESOURCE BASE OF FOSSIL FUELS AND OF URANIUM IN THE U.S.

FUEL	AUTHORITATIVE ESTIMATES OF U.S. RESERVES		RESOURCE BASE IN U.S.	
	QUANTITY	ENERGY EQUIVALENT IN Q	QUANTITY	ENERGY EQUIVALENT IN Q
CRUDE OIL	30.5 BILLION BARRELS	0.18	500 BILLION BARRELS	2.9
GAS	254 TRILLION CU. FT.	0.25	1200 TRILLION CU. FT.	1.2
COAL	950 BILLION SHORT TONS	24.0	2 TRILLION SHORT TONS	50
URANIUM (IN HIGH T&SP) FUEL CYCLE	500,000 SHORT TONS U_3O_8	0.2	300 BILLION SHORT TONS U_3O_8	120,000
URANIUM (IN BREEDING CYCLE — LOSSES UNKNOWN)	500,000 SHORT TONS U_3O_8	12–25	300 BILLION SHORT TONS U_3O_8	7,000,000 15,000,000

Chairman ANDERSON. You have to help us here a little bit on those figures.

Dr. STARR. Surely.

Chairman ANDERSON. Your chart shows that there is a fifth Q in uranium and 24 Q in coal.

Dr. STARR. Yes, sir.

Chairman ANDERSON. 125 times as much energy in coal in proved reserves as there is in uranium.

Dr. STARR. That is correct.

Chairman ANDERSON. We will have an awful big argument on that, I think.

Dr. STARR. These numbers have come from various official Government sources as to the proven reserves.

Chairman ANDERSON. Does the price factor have anything to do with that?

Dr. STARR. These are the proven reserves, but these are not necessarily the economic reserves.

I think you have a very good point which I might clarify here, and that is that this 24 which is available from the proven reserves of coal is not all on an economic basis.

Chairman ANDERSON. You have to put like things together sometime. If you put uranium on an economic basis, why do you put coal on an uneconomic basis?

Dr. STARR. The proven reserves on coal are much more extensive than the proven reserves on uranium. These are staked out reserves which are actually pinned down.

This number comes from the various geological surveys that the Government has put out for proven reserves.

Representative HOLIFIELD. Without regard to monetary value?

Dr. STARR. Yes.

Representative HOLIFIELD. In either case?

Dr. STARR. If you go to resources, they are only double in case of coal, but they go up by a huge factor in the case of uranium.

In other words, what this indicates is about a half of the coalbeds have been found already, but only a minor fraction or a minor percent of the uranium beds have been found.

I see Senator Anderson is interested in this particular point. I think I could probably get together the specific numbers on this and send these to you so you can see where they come from and on what basis.

Chairman ANDERSON. Very well.

We made some sort of survey of resources at one time, and I have probably forgotten it, but I do not recall that we calculated that coal energy was 125 times the present development of uranium.

Representative HOLIFIELD. That is not in tons?

Dr. STARR. No. These are in the form of the amount of energy you can get out of it by burning.

Representative HOLIFIELD. Without regard to cost?

Dr. STARR. Without regard to cost, but these are the proven reserves.

Many of these reserves in the case of the coal are very high-cost reserves. In other words, this is coal we know where it is. We may not want to pay to get it out.

Representative HOLIFIELD. Just as some of the uranium is high cost and some of it is low cost?

Dr. STARR. Yes.

I think the real point of this is that we have only found a very small amount of uranium which the geologists believe is there. We have found about half the coal the geologists believe is there. This is really what is responsible for this startling difference.

We have been looking for coal for hundreds of years and we have been looking for uranium for about 10.

If I may go on, then, if one considers the potential resources instead of known reserves, it is evident that even with the modest conversion ratios of most present power reactors, the uranium resources make a substantial increase in our future energy bank.

In the event that breeder technology can be successfully developed, the potential contribution of our uranium resources is clearly large enough to take care of our energy needs for many centuries to come.

Representative HOLIFIELD. This would indicate, then, that your research and development should be pointed pretty strongly along that line?

Dr. STARR. Yes.

I think the basis lesson from this, if one looked for a lesson, is that there is enough uranium to make a major world contribution for quite a number of centuries, certainly as far as we can foresee now.

Even with present reactors this is true, and certainly if you can improve the reactor and move in the direction of breeders, then you multiply this by a very substantial factor.

I think the long-term contribution to the energy resource of the world is substantial. This is not something which you can overlook. This is a very major contribution.

I think we have to recall, if I may digress for a moment, that we have been at this for about 10 years and the other energy source developments have been going on for hundreds of years.

I think we are just beginning to orient our situation as to what is worthwhile and what is not.

In summary, our studies indicate that for the foreseeable future our uranium resources are sufficiently large to support reactors which have been optimized for the lowest cost of power, even though they may not be the ultimate for the conservation of uranium. It is, of course, desirable that both long-term goals of economic power and uranium conservation be achieved, if it can be, as rapidly as our technological developments will permit.

The power produced by any reactor concept must be able to compete with the economics of our national utility system. Nevertheless, until the practical economic and operating aspects of the various types of atomic powerplants have been established, we must continue a broad spectrum reactor program. With about a century available for atomic power development before the resources problem becomes serious, we can expect major and presently unknown technical strides toward its solution.

Representative HOLIFIELD. This is an old idea which the committee has followed for a long time, and I believe that at this period in the development we should explore many different methods toward finding the right method of obtaining energy.

The new method as suggested by Chairman McCone of the AEC apparently seeks to concentrate all research in boiling water and pressurized water. What you are in effect saying is that we are still in the stage in the industry where whe should explore these different types of reactors rather than concentrate this time on one particular reactor.

Dr. STARR. Yes.

I think in addition to the fact that I am sure within the next 100 years there will be many technical developments that we don't foresee now which will change the whole picture of the kind of reactors and how they ought to be developed, I think the other point is that there is enough uranium developed from the mining industry at a very reasonable price to take care of operating these reactors on a purely economic basis.

You don't have to cut off a line of development because today it happens to use more uranium than you would like to see used over thousands of years. For this reason I am recommending that the spectrum of reactors we develop be as broad as possible. I feel very strongly we are too early in the game of reactor development to know which lines are really going to turn out to be the best.

Representative HOSMER. If they could do something with hydrogen, the whole picture changes or changes substantially.

Dr. STARR. I have not included the potential of hydrogen fusion as a form of energy. It is clear that if you had this, you would have another big energy source available.

I think it is also clear from the numbers here—again you have to compare these millions of watts available from uranium breeders with the watts that the country is going to need for the next hundred years or so.

It is obvious that for many centuries, even if you didn't have fusion development, uranium ore would be ample to take care of the energy needs.

Representative HOSMER. You say that we should achieve this uranium conservation objective as rapidly as our technological developments will permit. Does that mean in your mind a crash program or as rapidly as it will permit in the usual ordinary development?

Dr. STARR. No, sir; not a crash program.

There is a normal speed for technological development which flows from the rate at which technical information comes out of laboratories, research institutions, and the like. I am suggesting that we proceed with this normal speed of development.

Representative HOSMER. In relation to resources, we have sufficient of them to be able to proceed at the normal rate.

Dr. STARR. Yes, this is the point.

Representative HOLIFIELD. I would like to explore that because this is a new theory that we are being presented with, and that is the theory of a reduced tempo of development.

You said that the normal method of procedure was to explore each technological advance as we come to it.

Dr. STARR. Yes.

Representative HOLIFIELD. Let us go a little bit further and ask how do we explore each technical advance as it occurs. Do we do it on a nonsubsidized basis, or is the Government supposed to pick up

all these loose ends in this part, as some of us thought should be done, at least to a reasonable extent? Or should we step back now and let the normal course of development of atomic energy technology proceed at private industry expense.

Walk on that rope a little while.

Dr. STARR. Very well.

Congressman, I have in the past discussed the subject, and I will apply these points which I have made in the past.

First, I have been convinced for a long time that this program has to be supported on a national basis. There is no question in my mind on that for several reasons. One is magnitude; the fact that you cannot experiment back of a garage to carry on developments in this field. It takes huge organizations and large facilities to do it.

Secondly, that the national value of doing it is sufficiently great.

For these two reasons I have felt that there ought to be as strong a national support, a Government support, for the work as possible. Obviously the amount of effort which the Government puts into any one program has to be weighted with all the other demands on the Government.

This is a decision certainly beyond me, as to how much of the national wealth goes into this kind of effort. But given that amount of wealth going into the effort, there is a pace which automatically follows. It is hard to change this administratively. It is a problem of man versus nature in terms of finding new information, making engineering developments.

At that point the pace of carrying through a development for a specific goal, as for example uranium breeding, is determined by how quickly and how well information comes out of the various groups working on it. Once you have that pace, there is a natural timing which occurs. There is a timing for the research.

At some point the research goes into a reactor experiment. When that natural timing occurs, then the reactor experiment looks sufficiently interesting to go into a prototype, then the prototype should be supported.

Representative HOLIFIELD. We can control that pace or timing by not advancing any money to arrive at those various steps?

Dr. STARR. Yes, you can slow it down.

Representative HOLIFIELD. You can slow it down or you can allow it to take its normal course. When I say normal now, I am comparing it to the advancement of the automobile or some other great manufacturing projects in our history.

We have been told for the past several years that we were in competition with the Soviets to obtain an economic kilowatt from the standpoint of possible economic penetration of backward areas with cheap power sources. Now we are told, "Well, after all, the Soviets are not progressing very fast, they are having their troubles. They are drawing back and assuming a more leisurely place."

We are also told that in view of the fact that we need the money to put a man on the moon and other similar valuable projects, we cannot afford to develop this source of energy at a rapid pace. Just take it easy and let this thing go along at its normal course, normal meaning that it will be done in plenty of time. This type of ap-

proach to progress in the atomic energy field makes a great deal of difference to some of us on this committee.

When we thought we were competing with the Soviets, we thought maybe it was necessary to go ahead very fast. Now we find out that it is not necessary and I can think of a lot of things that are maybe just as important to put the budgeted money into as into this project, which may be very valuable a hundred years from now when we need it, but is not necessary today.

Dr. STARR. Congressman Holifield, obviously those of us who are in the industry and who have been in it a long time are more or less dedicated to moving with it as rapidly as we can.

From our point of view, I would shudder at the thought of slowing down and I would much of course like to see it speeded up as rapidly as possible. I was answering Congressman Hosmer's point on a crash program. I don't think that crash programs are necessary. But I do think support of what I would consider a natural pace that goes with the technical developments would certainly be justified.

Representative HOLIFIELD. We have been told that we must narrow down the projects in which we are interested. Obviously that means to boiling water and pressurized water. So some of you people who advocate other lines of approach seem to be left out of the picture.

Dr. STARR. Yes.

Representative HOLIFIELD. If we follow that advice and only build these steps in one or two pretty well-established lines of technology, we are going to have to ignore some of these other lines.

Dr. STARR. I think that from purely basic and scientific reasons, it is very dangerous to have a program narrowed down very early in its undertaking. I would be very surprised if within the next decades we don't change our sights completely as to what kind of reactors, for example, ought to be the reactors which are emphasized at some future period.

For this reason, I feel that the program has to be as broad as the national budget in effect will permit.

Representative HOLIFIELD. You point out the importance of the fast breeder. While we have some experiments going on in that area and one large reactor is being built in the fast breeder field, certainly in this line of technology there is need for constant attention to it.

Dr. STARR. Yes.

Representative HOLIFIELD. I would believe that the technology should be advanced as called for from the scientific standpoint.

Dr. STARR. Yes.

May I go on, Senator Anderson?

Chairman ANDERSON. You still have me in the arithmetic. I have not passed the first stage.

Can we agree that we will use about 950 million short tons of coal as the present reserve?

Dr. STARR. I can check that very quickly.

Chairman ANDERSON. If we can, then I have you up where a ton of uranium has only 14 times more energy than a ton of coal, and that is not the figure I have been using.

Dr. STARR. I have 2 million tons.

Chairman ANDERSON. 2 million tons?

Dr. STARR. It would be 2 billion. It is 950 billion short tons; the U.S. Geological Survey gave rise to this 24 Q. This 24 corresponds to 950 billion short tons.

Chairman ANDERSON. That was the figure that was in the McKinney report?

Dr. STARR. Yes. It would be twice that which are the resources that probably exist in the country. The 950 billion are actually staked out reserves of coal. But much of this is high-cost coal. So the economic factor which you mention, Senator Anderson, is not included in this.

Chairman ANDERSON. 237 billion tons are at present prices?

Dr. STARR. Yes.

Chairman ANDERSON. But they regard 950 billion as economically recoverable?

Dr. STARR. Yes.

Representative VAN ZANDT. You will not deny the increased use of coal, will you?

Dr. STARR. No.

Representative VAN ZANDT. The cost may go up from the mining standpoint, yet the efficiency in using coal is on the increase.

Dr. STARR. Yes.

I think there is no question but that coal versus uranium has to be on an economic basis for a long time to come. But the principal point again is that uranium is available if you are willing to pay for it in such supply that you are making a contribution for centuries to come by the development of this as a power source, and I think it has real natural value.

If I may go on, I would like to talk about the civilian power reactor program briefly.

In the past year the Commission has conducted a number of evaluation studies and has recently developed a civilian power reactor program. The Commission is to be commended both for undertaking this monumental task and for producing a well-rounded program. This is a valuable first step in what must be a continuous process of considering new, as well as old, approaches to atomic power and of continuously adjusting and initiating programs.

In view of pressure for early accomplishment and budgetary limitation, such program planning must guard against providing major support for only those reactor systems which promise economically interesting power in the immediate future. In spite of such pressure, there exists a responsibility to develop the best possible atomic power plants which both present and future technologies can produce.

Because of the present uncertainty in many important quantities which enter into reactor evaluation, a slight change in assumed values can completely alter the validity of long-rang projections. With such uncertainties, we must avoid the acceptance of oversimplified solutions to our complex planning problems.

In reviewing the recent civilian power reactor program of the AEC, there are certain general points which deserve comment. It is evident from the document that, in the opinion of the AEC, the light water reactors will soon be salable to the uituility industry on a competitive power cost basis.

This present status of the light water reactor concept is a demonstration that a sound technical approach can be brought to a commercial position with sufficient support. Substantially less support could bring other concepts to the forefront.

Over the long term, it must be recognized that every concept has its limitations and advantages; for example, the light water reactors are apt to be limited in power because of the limitation of pressure vessel size.

The recent attempt to include nuclear superheat within the same vessels will inevitably place an even more severe limit on the total power which can be obtained from a single reactor. Our utility industry has shown a trend to larger and larger central stations. For this reason, even though the light water concept is in the forefront now, the long-term trend may require the development of reactor concepts that do not have this size restriction.

Three concepts which have no restriction on size and which show promise for the future are being studied by our organization. I might briefly review their status with this committee.

The first is the organic cooled and moderated reactor, which is similar to the water type reactors except for the use of a low vapor pressure organic coolant instead of water. This permits operation of the reactor in the same temperature range as the water reactors but without the necessity of high-pressure vessels.

The OMRE, organic moderated reactor experiment, at the National Reactor Testing Station in Idaho was the first reactor experiment of this type and has since been used for a variety of tests.

Representative VAN ZANDT. What is the status of the OMRE at Arco?

Dr. STARR. It is in operation now. It is being used with a second core loading that has a series of experimental fuel elements in it.

Representative VAN ZANDT. Was it not down for a while?

Dr. STARR. It was down for the purpose of changing this core loading to add in these experimental fuel elements.

Representative VAN ZANDT. There was no fuel element problem. It was just a case of switching cores.

Dr. STARR. That is what the shutdown in the recent past has been.

The Piqua, Ohio, reactor will be the first operating prototype and is scheduled for completion next year. This project is proceeding smoothly in spite of the delays associated with the recent steel strike.

We are now trying to develop, with architect-engineers and the utility industry, proposals for a 50- to 100-megawatt version of the organic reactor in response to the Commission's recent request under the third round for such proposals.

Representative VAN ZANDT. Doctor, could we go back to the Piqua, Ohio, reactor?

Dr. STARR. Yes.

Representative VAN ZANDT. Have you any trouble getting the approval of the surrounding community on this project?

Dr. STARR. No, sir. We have gone through the rituals which everyone in the reactor business goes through with the Advisory Committee on Reactor Safeguards and the various licensing operation and the hearings.

Other than the fact that these rituals have to be gone through and the reviews require questions answered, we have had no particular difficulty. There has been no complaint from the community. As a matter of fact, the community has in its various pronouncements shown a sustaining interest in having the power plant there.

Representative VAN ZANDT. Could you translate into, say, months, the delay associated with the steel strike?

Dr. STARR. Yes. The steel strike held up the delivery of steel for the major containment building for the reactor, and, the way the plant had been engineered, this building had to go up before the installations could be made of other pieces of equipment. The overall effect was one of about 3 months or so. We schedule now that this plant will be completed not later than September 1, 1961.

Representative VAN ZANDT. Otherwise, you are on schedule.

Dr. STARR. Yes. This has been the only thing that has held us up. Like everyone else building reactors, we are trying to catch up this lost time, and we may be able to do some of that.

Representative VAN ZANDT. Thank you.

Dr. STARR. This reactor type is also uniquely qualified for maritime use, and it may be of interest to the committee that it is being seriously considered for this purpose by the British Admiralty and by a German shipbuilding group. In view of the relatively limited expenditures which have been made on development of the organic reactor, its performance potential, compared with that of the water reactors, appears very good.

Representative VAN ZANDT. Doctor, the consideration the British Admiralty and the German shipbuilding group are giving to this type of reactor; does it apply to a tanker-type ship?

Dr. STARR. Yes. In both cases it is a tanker about the magnitude of 60,000 deadweight tons.

Representative HOLIFIELD. Am I to understand that the United States is not interested in this particular development, and it is only the British and the German?

Dr. STARR. About 6 months ago we were requested by the AEC to undertake a study of this for the maritime application, and about a week or so after we undertook the study it was canceled. So, no work is being done in this country on it at the present time.

Representative HOLIFIELD. So, this is a gap in our development program which is apparently going to be filled by the British and Germans?

Dr. STARR. Yes.

Representative HOSMER. I am not too sure. Dr. DeHoffman came in here and tried to sell us a maritime reactor the other day, and you are trying to sell us one, only Mr. McCone, I think, resisted the temptation. I wonder if these sections 202 hearings are commencing to be a sale demonstration, for maritime reactors, or what?

Dr. STARR. No. I thought it would be of interest to the committee that this reactor is being used, or is being studied, by other countries for maritime use. It was seriously enough considered by the AEC to have had studies made in the past years. To reply to Mr. Holifield, no such study is underway now.

Representative HOSMER. In case it does not come up later, I want my position on record on this thing as being the same as last year.

Until somebody can show me that anybody besides the big oil companies are going to get a benefit out of maritime nuclear tankers, I would not have any part in spending the taxpayers' money on them.

Representative VAN ZANDT. Mr. Chairman, at this point I think the record should show that while the North American people did not get a study project, yet the AEC did award a study project to several other companies.

Dr. STARR. Not, I believe, on the organic application for maritime tankers.

Representative VAN ZANDT. I am speaking of the gas-cooled-type reactor.

Dr. STARR. Yes. I am sure the AEC is interested in the maritime applications.

Representative VAN ZANDT. And boiling water, also.

Dr. STARR. Yes. The AEC is obviously interested in the maritime application. I think in my previous testimony to this committee in the past years I have indicated this is probably one of the most interesting applications for atomic energy.

Representative VAN ZANDT. Doctor, do you know what type of reactor Babcock & Wilcox is working on?

Dr. STARR. That is a pressurized water.

Representative VAN ZANDT. Pressurized water?

Dr. STARR. Yes, sir. I might point out, Congressman Hosmer, that I think it is probably correct that the contractors responsible for the major reactor programs indicate to the committee the various aspects of their program which are pertinent to the atomic energy field. Certainly, if they don't, there would be no other nongovernmental witness particularly interested in doing so.

Representative HOSMER. Thank you, Dr. Starr. Any other time you have an answer to a question that has not been asked, please feel free to give it.

Dr. STARR. Yes, sir. If I may go on, I would like to talk about the other reactor types, the development of the liquid sodium-cooled, graphite-moderated reactor has continued steadily, with the Hallam reactor for the Consumers Public Power District of Nebraska, the first operational prototype, scheduled for completion in October 1961.

It should be remembered that this type of nuclear superheat reactor not only provides superheated steam, but also permits the eventual achievement of thermal efficiencies well above 40 percent, which is higher than most other reactor systems, even with special nuclear superheat sections. In addition, the development of uranium carbide fuel, which is now proceeding rapidly, could represent a true technological breakthrough in the performance of the sodium-cooled reactor.

We anticipate that with this fuel the fuel-cycle costs will be less than 2 mills per kilowatt-hour. In addition, it is expected that the next engineering version of this type of plant could achieve capital costs sufficiently low as to make this concept extremely competitive with other reactor types.

Representative VAN ZANDT. Doctor, at this point, what happened to the proposal to build into the Hallam reactor facilities for irradiating food?

Dr. STARR. This proposal was made to the Atomic Energy Commission when the title I design was being formulated. It would have required some small additional expenditures in the building. At that time the Commission did not consider that the expenditure for a radiation source would be warranted. I gather that there just was not, in their opinion, sufficient general interest in the use of such a source to warrant making that provision. This could be done at a later date if it was so required.

Representative HOLIFIELD. Dr. Starr, Mr. McCone has already stated to this committee that work on the sodium-cooled reactor should not be expanded until we get the operational experiences at the Hallam plant.

You said that you believe it is timely to initiate some additional work on a second sodium-reactor experiment. Do you mean a reactor experiment that would go beyond the present engineering of the Hallam plant?

Dr. STARR. Yes.

You are anticipating me a little bit in my approach here, but I might say that we have, under the general study program we have been conducting for the Commission, been developing engineering improvements over the Hallam plant. The Hallam plant is conservatively designed and is based upon engineering technology which was available 3 or 4 years ago. It is going to be, I think, a very good plant, and its operating characteristics are going to be very acceptable to the customer. Its cost of construction is higher in terms of dollars per kilowatt than what one would eventually like to have for a competitive plant.

The engineering features which have given rise to this high cost have been subject to a considerable amount of development. We are now ready to take these advanced engineering concepts and put them into another reactor experiment to prove out this advanced system.

We think that with this advanced system the sodium reactor becomes a very exciting one from the point of view of performance. We feel that, technically, we are ready to move into the next step, the next step being a second reactor experiment.

Representative HOLIFIELD. And these are advances which you can at this time put into the Hallam reactor?

Dr. STARR. They are advances which cannot be put into the Hallam reactor because that design is frozen; it is under construction, and one cannot change the construction of a plant in midstream. But the advances make a considerable improvement in the concept of the plant and would represent a next step. We feel that we are ready for this next step now.

The uranium carbibe fuel is an example. It has been under test now for some time and looks sufficiently interesting that, if we could have found a way of getting it fabricated in time, it would have been considered for the first Hallam loading, which will take place in early 1962. As a matter of fact, we are getting into the first Hallam loading some percentage of uranium carbide fuel. This fuel plays the same role in the sodium system that the uranium oxide does in the water system. It is a very high-burnup, high-temperature fuel.

The small-scale experiments all look sufficiently good that if this

were put into a large reactor it would make the fuel cost of the large reactor very low.

Representative BATES. Doctor, can you give us an average figure today on the fuel-cycle cost compared with the 2 mills per kilowatt-hour you have given us here?

Dr. STARR. Yes. They vary for the size of the reactor and how one calculates it. But they run somewhere about 4 mills a kilowatt-hour today.

One of the reasons is that we are today using uranium metal fuels which have a temperature and burnup limitation in performance. They have to be taken out for reasons of self-growth of the fuel and changes in the fuel before you used up enough uranium to make it economic.

Representative HOLIFIELD. As the second cores are made in these reactors of very improved performance, are you referring to the overall average or the first core or second core?

Dr. STARR. I am referring now to the use of uranium carbide fuel as a subsequent loading for a sodium reactor.

For example, in the Hallam reactor the first loading will be uranium metal. The second loading will be uranium carbide. We are sufficiently enthused about this particular fuel if we could have gotten it into the first loading we would have done that.

It is this type of development, which is proceeding rapidly, which makes us feel that it is timely to get a second reactor experiment underway.

If I may go on, because the technology of sodium-cooled reactors is similar for both thermal and fast cores, the program for development of this technology is applicable to a variety of concepts.

For example, our organization is conducting for the Southwest Atomic Energy Associates, a group of private utilities, an extensive study of the advanced epithermal thorium reactor which contemplates the use of a thorium U^{233} cycle in a fast neutron spectrum core, optimized for power economics rather than for conversion ratio. The critical facility for determining the nuclear constants of this uniquely fueled core is now under construction, and we will shortly be able to establish the design characteristics for this concept. This reactor is similar to the fast plutonium breeder, except for the fuel used.

The AEC's civilian power reactor program includes this type as part of (75f) its new concepts program.

Because of the advances made by many groups in the development of components and design concepts for liquid-sodium-cooled reactors, we believe it is timely to initiate in fiscal year 1961 the construction of a second sodium reactor experiment, incorporating these new developments.

The first sodium-reactor experiment, which was placed into operation in April 1957 was originally for the purpose of developing the engineering information for the Hallam reactor, is now planned as a high-temperature fuel test facility, and cannot be used to test radically new engineering configurations.

As a way of avoiding pressure vessel-size limitation in water reactors, it has often been suggested that pressure tubing be utilized. This concept is being considered by the Canadians and the Soviets. It appeared sufficiently interesting for reasons of safety, low main-

tenance, and general performance, that the Nuclear Power Group, NPG, a group of private utilities, originated a study which recently was conducted in collaboration with our organization. The reactor concept, a graphite-moderated, boiling-water, superheat reactor, GBSR, utilizes a fundamentally different approach of physically separating the uranium fuel from the water and steam channels. It appears to warrant further consideration leading to a reactor experiment. The GBSR is also included (75h) in the AEC's new concepts program.

Representative HOLIFIELD. Could I stop you there, please? I was shown a very interesting experiment which is supposed to take care of this factor of the large containment vessel. I think they call it the suppression principle, where the pressure is piped off into a body of water rather than having a metallic dome to contain it.

Dr. STARR. Yes.

Representative HOLIFIELD. If that works out—I do not know just what stage the experiment is in at the present time—I assume that would apply to pressurized-water- or boiling-water-type reactors. If that works out satisfactorily, that would obviate the necessity of having these large containment domes which are pretty expensive and difficult?

Dr. STARR. Yes. That is a developmental device for reducing the size of the containment building that holds all the reactor and all its devices in the event of a condition which bursts the reactor proper and puts steam and other products into the reactor building.

Representative HOLIFIELD. But not the immediate containment vessel for the reactor itself.

Dr. STARR. It is not the vessel which holds the reactor core and which holds water at several thousand pounds per square inch of pressure. It is that vessel which is an engineering problem which places a limitation on how big you can make the core.

Representative HOLIFIELD. I see. That theory would not solve the containment vessel for the reactor, but merely the size of the building or the backup, you might say.

Dr. STARR. That is right.

Mr. RAMEY. On this GBSR reactor, is this the same general type that the Russians are working on?

Dr. STARR. It is similar in the basic philosophy of trying to separate the fuel from the coolant channel. The GBSR is primarily devoted to removing what could be a difficult maintenance problem. They have taken the fuel and placed it in one part of the reactor and the coolant channels some distance away, separated by a graphite moderator. So, if anything happens to the fuel, it will not get into the coolant channel.

The Russians have a fuel element which they have been developing for years which, if it fails, does not get fission products into the coolant channel but goes into the rest of the structure.

The GBSR has three sections. It has a boiling section and two superheat sections which are steam cooled. It permits, like all the large graphite reactors, extension in size, and it also looks as though it will reduce the maintenance problems which go with various reactor types. For this reason the utility group was quite interested in exploring it.

We have just completed what amounts to a feasibility study and we hope to continue these studies.

Mr. RAMEY. What size are you thinking about on this kind of reactor?

Dr. STARR. It is being looked at for 300 electrical megawatts, but one of the characteristics of this type of reactor is that it has no size limitation other than just physical structure. From the point of view of the utility industry, by the time you wanted it, you would be talking about 500-electrical-megawatt machines.

I might point out that the British reactors and the French power reactors that are now being built are all in the 500-electrical-megawatt size. I am sure as time goes on the utility industry in the United States that utilizes big plants will be thinking of plants of 500 electrical megawatts.

Representative HOLIFIELD. What size plant would it take to prove this concept out?

Dr. STARR. As a reactor experiment, we are talking here of something which tests out the engineering system and which would be of the order of 10 or 20 megawatts. It would be a small experiment.

Representative HOLIFIELD. It could be along the size of the Santa Susana or Vallecitos plant as a step in the technology.

Dr. STARR. Yes, sir.

As a more general comment, I believe it is extremely important that the Commission continue to emphasize the areas of fuels and materials. In particular, the development of low-cost methods for the remote fabrication and pyrometallurgical processing of pultonium and thorium fuels must be rapidly accomplished. The cost associated with these processes may be a key determining factor in the eventual utility of both thorium and pultonium cycle reactors, including the fast breeder. I have previously indicated the long-range importance of the plutonium cycles.

In recognition of the international objective of our program, it becomes additionally important that we incorporate in our planning the opportunity for major nuclear advances. The development of atomic power in the nonindustrial nations of the free world will cover such a span of decades that advanced and as yet undeveloped concepts may play a significant role. We should have the foresight to recognize the importance of new concept development, and provide opportunity for this in our planning.

Representative HOLIFIELD. Doctor, have you had a chance to talk to any of the Russian atomic scientists?

Dr. STARR. They have been out to visit us; yes.

Representative HOLIFIELD. Do you feel that they have been frank in telling us what they are doing?

Dr. STARR. I think they have been very frank in telling us what they have done. I have no way of knowing whether they have told us what they are doing. I think there is a distinction here. It is my impression that, after they have something completed and well underway, we hear about it. We were not able to get much indication of what was in the conceptual development stages in their program.

Representative HOLIFIELD. We know that they are building several different types of reactors. Did they give you any real information on the type that they are building now?

Dr. STARR. Only what has been made public.

Representative HOLIFIELD. Have they talked more or less about the Dubna plant and the others they have allowed visitors to see?

Dr. STARR. The only reactor types they discussed they have already publicized and Mr. McCone gave a review of these when he returned from Russia, I believe. They indicated to us a considerable amount of interest in the organic reactor and left our own people with the impression that they were undertaking work in building an experimental organic reactor. But there has been no official pronouncement of any sort on this particular program.

Representative HOLIFIELD. Were their questions of high professional character in the organic-moderated technique?

Dr. STARR. I didn't get the question.

Representative HOLIFIELD. The point I was trying to find out was if their questions indicated considerable knowledge in that technique, or were they exploratory?

Dr. STARR. Their questions indicated a degree of sophistication which would only exist with people who have been working on this kind of technique.

Representative HOLIFIELD. I do not think we have any knowledge at all of the specific reactor they are building at this time.

Dr. STARR. They have not officially made any announcement of this sort.

Representative HOSMER. Before you proceed to the next section, earlier in this section of your testimony you warned against providing major support only for reactor systems which looked immediately economically feasible, and suggested a responsibility to work on a broad range aiming at the best possible reactor.

My question is going to be, Why should we do this? and, in preface to that, let me say that everybody comes up and says we should do this and nobody says why.

I may be unkind, but when you talk about the fuel cost of a reactor right now at 4 mills and you imply that you are going to have it at 2 mills the real difference is slight. There are a lot of people that share my suspicion that had we developed steampower for automobiles we might be better off than we are with gasoline engines. But we never got around to that for one reason or another. Yet we are getting along pretty well anyway.

This is the context that I address my question to this particular business here.

Dr. STARR. If I might answer your question as succinctly as I can, there are several points involved.

One is that if there was complete assurance that any one particular approach was really as good as any of the conceptions that anyone had, and it was likely to meet all our needs for the future, I think anyone in the reactor business that intended to stay in the business would climb on the bandwagon of that particular approach. The fact that this is not being done is an indication of a considerable amount of technical questioning as to whether in the long run this particular approach, or any one particular approach, is going to give the proper answer.

Representative HOSMER. That is true, but then we get into this business of what is the long-run gain. Why should we in the next 50

years be striving for anything less than 2 mills per killowatt-hour as a fuel cost and maybe after that generate something at down to one or half a mill?

Dr. STARR. I believe I can answer that question, but if I may just give a homely analogy for this. When a boy is born into the family, some people determine his career immediately. Some wait until he has gotten into high school. We are still in the infancy stage in this business. I think it is premature now to freeze the course that this business is going to take indefinitely. The Government can very well do this just by the magnitude of the nature of the work that has to go into these programs.

I think we have got to wait at least until we get into the adolescence of the business.

I would guess in the next 10 years we are going to be going through that phase and we are going to get a much better idea of what are the key issues, what are the key problems, and what are the key solutions which determine the reactor types that ought to be concentrated on, at least for an ensuing time.

If one considers that until about 6 or 7 years ago the amount of work on power reactors was very small, you can perhaps get some feeling that we are just beginning to sound out the various technical aspects. I think it is the fact that we have just begun to explore all the technical problems that have to be solved to make these plants useful to a utility operation that makes us hesitate now to pick a few to push.

Representative HOSMER. Then you would quarrel with this committee, which has always been pushing the Commission to get faster into economic power and get some kind of program because we have to have it in X number of years, 10 years, 5 years in this area and so many years in that area, and you would rather say, let this thing develop in the theory of trying to find what is really best rather than to force economic considerations too closely around its neck?

Dr. STARR. I don't think I have a quarrel with the committee.

Representative HOSMER. I would not expect you to admit it today if you did.

Dr. STARR. I think that the interest of not just myself but I think all of us in the field is to see the progress made as rapidly as possible. I don't think there is a great difference of opinion in the field that it ought to be made on a variety of approaches.

When you are trying to get somewhere, the fact that the horse gets whipped for various reasons is perhaps secondary to the fact that he gets whipped at all.

We would like to see progress made. I will not quarrel or even try to defend having economic power at a specific date because, frankly, I don't know what that means. This has been a subject of great discussion for some years, and I am sure you will get as many opinions on this as there are people to speak.

I think there is a worthwhile national goal in moving ahead as rapidly as possible with the field. I think it ought to be on a fairly broad front. This becomes a matter of technical and engineering management philosophy rather than one of pinning down a specific date at which something has to be done.

Representative HOSMER. That is the reason I brought it up. So often we speak in terms of progress or lack of progress when actually we need to examine our philosophy as well.

Dr. STARR. Surely.

Representative HOSMER. Go ahead.

Representative HOLIFIELD. Dr. Starr, I think the committee's position in the past has been to explore various fields. We have also insisted that each field follow the so-called staircase method.

As the technology increased, we would step from the experimental loop to the small reactor and then to a prototype and then to a full scale. It is pretty well known that there was an attempt to write into Euratom only two kinds of reactors, boiling water and pressurized water. Some of the members of the committee objected to freezing the Euratom program to two types.

We included language in the legislation and in the report to indicate that other approved types of reactors would be considered on the basis of the consumer's desire to have a particular type of reactor.

Dr. STARR. Yes, sir.

Representative HOLIFIELD. I think that has been the committee's position. But, if the urgency of achieving economic power from a national standpoint has now abated somewhat, it seems that we can reevaluate the timetable and possibly put more into research and less into the immediate goal of obtaining an economic kilowatt regardless of the type.

If we accept the philosophy that there is no longer any national urgency, then I think two things would evolve from that. One would be a curtailment of Federal appropriations into this field, which I can see you would not be in favor of, necessarily.

The second thing would be going into more of a research and development effort in a more varied number of types of reactors, if this philosophy is accepted, and it seems to have been accepted by the administration as indicated in Mr. McCone's statement. I have not accepted it permanently yet, but I am considering it very carefully.

Dr. STARR. I think, Congressman, my feeling is that we ought to make progress as rapidly as we can. We ought to make it on a broad front.

One can get, I am sure, all kinds of solutions to how one proceeds.

Representative HOLIFIELD. If that philosophy was adopted and we had X amount of money to appropriate from the Federal standpoint of helping in this industry, would you advocate the utilization of that money in varied types of approaches rather than in concentrating on one or two rather advanced types?

Dr. STARR. Yes. I would recommend that the money be used in various types of approches. Again, I think we have to recognize that at some point the utility industry itself begins to feel an approach has reached the stage where they, as a private group of people devoted to the power industry, can begin to make investments of their own.

Representative HOLIFIELD. That is all right. I am not averse to that.

Dr. STARR. This has occurred in the water reactors, specifically. I think the principal point I am trying to make is that, as time goes on, the other reactor approaches ought to be supported and many of

these will reach the point again where the utility industry will begin to pick these up. I am definitely against concentration of the moneys available on just a very few types. I feel we are not ready for it.

Representative HOLIFIELD. If the international competitive urgency is removed, there is no reason for us concentrating on one or two types?

Dr. STARR. That is right, sir.

The next topic that I was going to develop was the work on space power applications.

Another area of the Nation's atomic development that offers a unique opportunity for implementing future planning is the use of nuclear reactors for auxiliary power, both military and nonmilitary space missions.

Our country today finds itself engaged in a tremendous program for the development of the basic boosters and vehicles for space and satellite missions. This program is one of the largest items in our national budget. The booster program recognizes that, because of the long development lead times required, it is necessary to plan and develop booster capabilities independently of specific missions. As Dr. Hugh L. Dryden, of NASA, so ably emphasized in his recent congressional presentation of the space program, because of this lead time it is essential that, in addition to the development of boosters, the development of payloads and all the auxiliary equipment that goes with them must be undertaken in parallel.

A review of the projected plans for the development of the very large boosters, the magnitudes of the payloads which they may be able to carry, provides an indication of the electrical power which they may require for various missions.

If I may go to the next chart (chart 6), perhaps I can explain this. This chart indicated the purposes to which one would need electrical power in space. If I may explain this chart, on one side is, unfortunately, a technical term called signal-to-noise ratio. I think if you have tried tuning in your radio and have found the voice lost by static, this signal-to-noise ratio is about 1. If you tune in a TV program from a distant station, and it is washed out by patterns, that signal-to-noise ratio is about 1. The higher the signal-to-noise ratio, the clearer the reception.

On the lower part of the diagram, we have the electrical power that the transmitter has to have to do its job. If you consider radio transmission from a space vehicle—let us assume we had a satellite rotating at 300 to 1,000 miles above the earth's surface and it is there for communication purposes of various types—this is the amount of power you need. If you have a focused transmitting antenna—this is one of these big radar balls that focuses down on a specific city or a specific location—if you have up to about 100 watts of electrical power available, you get fairly good reception on the receiving end of the radio signal.

These are types of things which are now being talked about using the solar photocells for energy. If you get much less than this, you begin to get into the area of poor reception. If you talk about using a transmitter for radio which covers a whole country—it is not focused to a specific city—then you need about 10 times as much power for good reception; about a kilowatt.

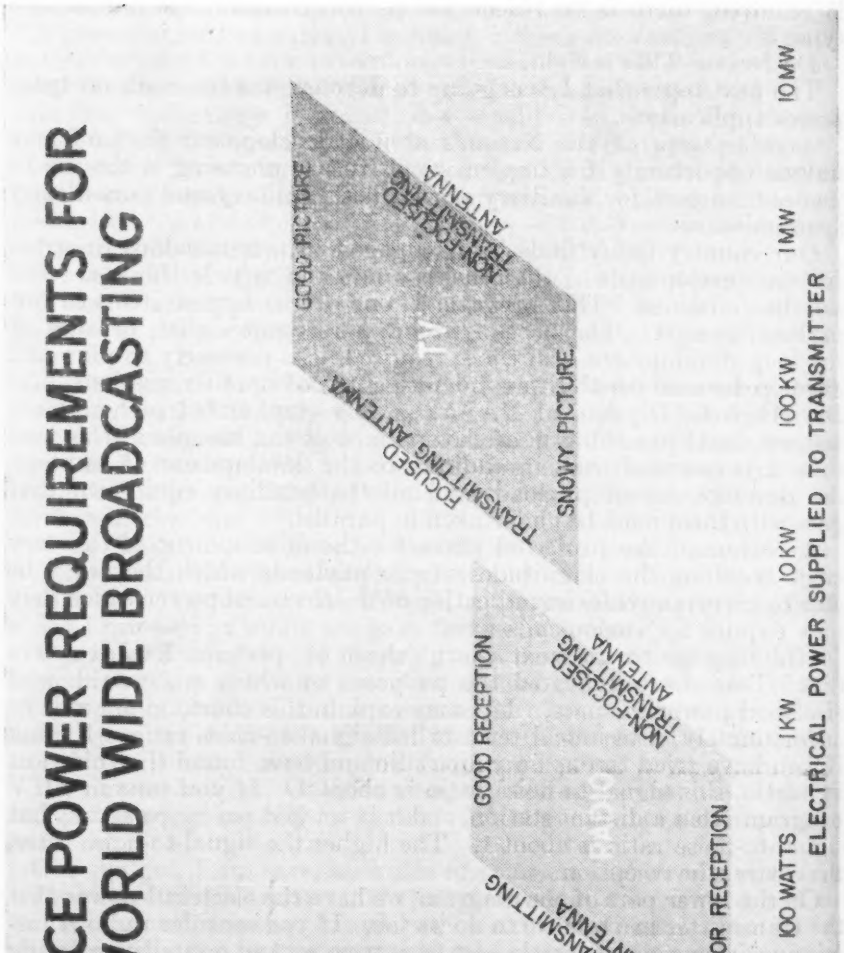


CHART 6
SPACE POWER REQUIREMENTS FOR WORLD WIDE BROADCASTING
SIGNAL TO NOISE RATIO
1000
100
10
1
RADIO
TV
FOCUSED TRANSMITTING ANTENNA
NON-FOCUSED TRANSMITTING ANTENNA
GOOD RECEPTION
POOR RECEPTION
FOCUSED TRANSMITTING ANTENNA
NON-FOCUSED TRANSMITTING ANTENNA
GOOD PICTURE
SNOWY PICTURE
10 WATTS
100 WATTS
1 KW
10 KW
100 KW
1 MW
10 MW
ELECTRICAL POWER SUPPLIED TO TRANSMITTER

About this point you are beginning to hit the limit of what you can get out of solar cells under reasonable development at the present time.

Representative HOSMER. When we get to this 1 kilowatt, let us relate that to something we can understand. We hear about this 50,000-watt, clear-channel radio station. Where does that fall in?

Dr. STARR. This 1 kilowatt is the power supplied to the transmitter. The 50,000-watt, clear-channel stations are extremely powerful. They would be 100 times as powerful as this kind of thing. You can actually receive these 50-kilowatt stations a good distance away. Transmission from space to earth is in many ways easier than over the surface of the earth.

Representative HOSMER. Relate it to the transmitting stations.

Dr. STARR. These are very small. If you go to TV transmissions—we have talked about using these satellites to give TV transmission to people on the earth's surface—the power requirements are very much higher. Here, again, if you have a focused transmitting antenna—suppose you are over a particular city like New York and you want to focus down on New York City—no one wants a snowy picture. If you want a good picture, you would have to have roughly about 100 kilowatts of power. These are for space power sources. These are huge power sources now. I will come in a moment to how to get this.

If you are talking about spreading TV pictures over a big area of the country now, you are talking about having maybe a megawatt of electrical power. The principal purpose of this diagram is to show that if we are going to use the powerplants in space for communication purposes, both radio and TV, we have to get up into sizable power sources. It is in this area where nuclear power, I think, plays the role.

The next chart (chart 7) shows you what actually is being proposed in terms of various missions for large boosters which we are supporting in this country. Here is the year in which they have been discussed as being flyable. You will see that the payloads these large boosters carry, the very nearest one in time, which is in the next year or two, will only carry 1,000 to 1,600 pounds. But after that they are talking about 10,000-pound payloads. Then, later on, in maybe about 8 to 10 years, we are talking about 30,000-to 100,000-pound payloads.

If you talk about the power that would go with these missions, I have them listed here and would be happy to have you go over these at your leisure. We are talking here again of kilowatts.

Representative HOSMER. I just cannot conceive of how you did anything but get those figures out of a crystal ball. Is that where they came from?

Dr. STARR. No, sir, these did not come out of a crystal ball. These came out of the space program which has been reviewed in great detail.

Representative HOSMER. As to just exactly what those particular things are going to do when they get up in the air and how many transmissions they will make?

Dr. STARR. No; the payloads are the ones that have been discussed as the purpose of these vehicles.

ELECTRICAL POWER SUPPLIED TO TRANSMITTER

CHART 7

AUXILIARY POWER FOR LARGE BOOSTER PAYLOADS

YEAR	BOOSTER	BOOSTER PAYLOAD	INITIAL ORBIT	POWER REQ'D	MISSION
1962-63	ATLAS-CENTAUR	1000-1600 LB	22,000 MI.	400-800 WATTS	COMMUNICATION SATELLITE IN 24-HOUR ORBIT
1963-64	ATLAS-CENTAUR	10,000 LB	300 MI.	2.2 KW	FLIGHT TEST OF ELECTRICAL PROPULSION
1964-65	ATLAS-CENTAUR	10,000 LB	300 MI.	3-6 KW	MANNED SPACE LABORATORY
1965-66	ATLAS-CENTAUR	10,000 LB	300 MI.	30-60KW	ELECTRICAL PROPULSION FROM LOW ORBIT TO 24 HOUR ORBIT
1965-66	ATLAS-CENTAUR	10,000 LB	300 MI.	72-140 KW	UNMANNED LUNAR SATELLITE
1967-68	SATURN-CENTAUR	30-40,000 LB	300 MI.	500-600KW	MANNED LUNAR CIRCUMNAVIGATION AND UNMANNED INTERPLANETARY PROBES
1968-72	NOVA-ROVER	100-300,000 LB	300 MI.	1-10 MW	MANNED INTERPLANETARY PROBES

(ELECTRICAL PROPULSION AND AUXILIARY POWER)

Representative HOSMER. But the power requirements?

Dr. STARR. The power requirements are those that are associated with the missions that have been discussed for this kind of vehicle. If I may just point out to you, this one is a communication satellite with a 24-hour orbit. This is an electrical propulsion device for space propulsion. This is the manned space laboratory. This is the electrical propulsion which takes a vehicle from low orbit, a 300-mile orbit to a 22,000-mile orbit. These are all missions that have been discussed as being possible missions for this kind of payload. Here is an unmanned lunar satellite.

Representative HOSMER. You want 72,000 to 140,000 kilowatts of power for unmanned satellites?

Dr. STARR. Yes, sir.

Representative HOSMER. You have to have a television station on it.

Dr. STARR. It depends on what you use it for.

Representative HOSMER. Is that how you get those requirements?

Dr. STARR. Yes, sir. From the particular kinds of missions which have been discussed as being the kind of thing you would do with this payload. What we have done is take a look at the amount of power that kind of mission would require. If you make that study, you find that you are talking here in the range of hundreds of kilowatts of electrical power to do this. The principal point is that this is an area in which nuclear power can supply this electrical power.

Representative HOSMER. Does that anticipate developments in these electronic equipments that will reduce the required power, and so on?

Dr. STARR. Yes. The developments in electronic power do not reduce the power required to do the transmission. They reduce the size and weight of what you can carry. The more you reduce the size and weight of what you can carry, the more power you will need, because you are going to put more things on it. So, I think you will find, sir, that these are not inconsistent numbers with what has been discussed.

Representative HOSMER. I suppose they are not inconsistent numbers, but I really can't convince myself that they are a firm requirement.

Dr. STARR. Firm requirements they are not. I think this is another part of my talk, if I may go on with that.

Representative HOLIFIELD. While they are not firm requirements, it is true there is no use putting up a 10,000-pound booster payload unless you know what your payload is going to be.

Dr. STARR. Yes, sir.

Representative HOLIFIELD. This is in line with all of the briefings that I have had. I would like to ask you this question. Can you, without going into security, give us the comparative efficiency of the SNAP development of your company in regard to the kilowatts produced and the time of use as against the battery load which we have used in our previous lightweight satellites in terms of percentage?

Dr. STARR. I think I have this in the testimony, if I may go on.

Representative HOLIFIELD. Very well.

Dr. STARR. The principal point of the chart was not to argue for a specific mission. It was to establish this point. It is evident that, as the payloads get larger, their power requirements will similarly increase if we are to make the full use of the payload capabilities.. I think this is the key point.

In view of the fact that all of the valuable missions involve very long times of operation, the only energy sources that can be seriously considered are solar radiation, radioisotopes, and nuclear power. For small power requirements, solar radiation is certainly adequate, as are radioisotopes. However, as one proceeds from a few kilowatts into the megawatt range, the physical problems of utilizing solar radiation or radioisotopes become so immense that the attractiveness of nuclear power is very great. It is for this reason that the development of the system for nuclear auxiliary power (SNAP II), designed to produce 3 kilowatts of continuous electric power in space, has been considered a significant milestone. The SNAP program is sponsored by the AEC Office of Aircraft Reactors. Our organization has been pleased to have had the opportunity to contribute to this development.

Representative HOLIFIELD. If you could produce 3 kilowatts of continuous electric power in space, this makes the mission of the manned space laboratory immediately feasible, as far as your auxiliary power is concerned?

Dr. STARR. Yes, sir. The SNAP II is intended for a space-vehicle use of some kind which would cover this particular range of 1964–65 in the space program.

Representative HOLIFIELD. In other words, you are at this time able to satisfy power requirements necessary for the space program, although we are a long way from it from the standpoint of propulsion.

Dr. STARR. Yes. I think that, in terms of meeting the immediate power requirements for the next few years, we have under development in SNAP II the nuclear-power source that will do this.

Representative HOLIFIELD. Are you allowed to tell us what that weighs, either percentagewise or actual pounds, with the amount of batteries that would be required to produce 3 kilowatts?

Dr. STARR. I could probably get the number for the batteries required to do what the SNAP II does. I think it would be enormous, simply because the SNAP II is supposed to provide power in space for 1 year. The batteries are matters of weeks. I don't think anyone could even consider batteries for very longtime use.

Representative HOLIFIELD. So, you say it is a milestone. It is a real milestone.

Dr. STARR. Yes, sir. The only thing that could possibly be used as a substitute for this would be solar cells, and here we are talking about something which in terms of weight and in terms of cost is anywhere from 5 to 10 times greater; that is, the solar equipment would be 5 to 10 times greater than the nuclear equipment for this range of power. If you talk of 30 kilowatts as the next stage, or higher, you get to 10 or 100-kilowatts, the solar equipment is about 10 times as costly and about 10 times as heavy.

In addition to the rather huge engineering problem to handle these reflectors out in space, which are hundreds of feet in diameter, there is a very serious problem as you get into these later boosters

and later missions, which the SNAP development as a starter could handle.

Representative VAN ZANDT. What is the status of SNAP II today?

Dr. STARR. We have completed the initial operation of what we call a "breadboard reactor." This is the reactor itself placed in the ground so that we can work on it. It has been operating now for about 6 months at full temperature, which is about 1,200° F., and full thermal power, which is very close to 50 thermal kilowatts. The Thompson Ramo Wooldridge Co. is developing the power conversion system. This is a mercury turbine and generator. We hope in the year to tie the reactor and turbine-generator together in a unit. We are hoping the schedule will match the needs that are indicated here on roughly the time scale here of 1964–65.

Representative HOLIFIELD. Dr. Starr, as you know, I have visited your plant and have seen this SNAP reactor in operation. I think your company is entitled to high congratulations for developing this. It is a quantum jump in my opinion in the control of instruments in space.

Dr. STARR. Thank you, Congressman Holifield. We are obviously enthused about it, and we are pleased you find it satisfactory.

Representative HOLIFIELD. Would there be any reason why you could not bring one of those reactors to Washington sometime? Is there any reason for security or other reasons?

Dr. STARR. No. I think when the unit is eventually put together as a composite unit, both its size and weight inevitably make it transportable because the weight requirements for space are obviously very small.

The leadtime required for the development of a space nuclear power source is considerably greater than that associated with a land based, or otherwise accessible, unit. In view of the high cost associated with each flight test with one of the very large boosters, the space nuclear power unit must have a degree of reliability, under the most severe mechanical conditions, which is not easily achieved. To develop such a degree of reliability requires an extensive series of ground test and shakedown programs in specialized facilities. Furthermore, the power conversion equipment, which utilizes heat from the nuclear reactor to produce electrical energy, is likely to be itself a novel development, either in the form of rotating machinery or in the form of one of our more advanced thermionic converters. For all these reasons, the leadtime for the development of a space nuclear power source, which is qualified in all technical aspects for a first flight test, is of the order of 5 years or more.

Fortunately, the technical approach used in the development of the SNAP II plant permits a logical program extension to increased power outputs up to the megawatt range. Such a program could provide a continuous series of space power units with steadily increasing power outputs, matching the present national space vehicle program.

It is interesting that the present lack of specific requirements for large space power units arises from a type of circular reasoning. Those responsible for the objectives of the payloads and missions, utilizing the large boosters, have not seriously considered designs requiring large amounts of power simply because suitable powerplants

may not be available in time. On the other hand, formal requirements for high power space plants are not established because the designers are not proposing vehicles which require high power.

As booster vehicles become larger and more costly, it is mandatory that their payloads, useful life, and endurance must be reliably extended in order to obtain maximum economy of mission operation. It is characteristic of vehicle designers that they "strip down" the requirements for auxiliaries in the early stages of any program with consequent limitation of the mission. When the program matures, the scope of utilization of the payload grows, and with it, power requirements. As a typical example, it is interesting that the electrical power requirement of the B–52 heavy bomber has increased about threefold from the time of its initial inception.

Until the advent of the SNAP II development, the nuclear auxiliary power unit was considered a fanciful concept. We still have much engineering and testing to accomplish before we have a power unit qualified for flight. However, the performance to date of the experimental reactor has been eminently satisfactory, and there is no question that it can be made a successful operational power source.

In addition to the use of these compact powerplants for space vehicles, it will undoubtedly be evident to those of you who have concerned yourselves with the intricacies of our military requirements, that such powerplants would have many other uses. Space requirements represent the most demanding in terms of reliability, mechanical ruggedness, compactness, and low weight. If a family of power units can be developed to meet these requirements, they could easily become valuable adjuncts to many of the military devices where compact, long-endurance power sources are needed.

For all these reasons, it appears to be in the national interest that a long-term program for the development of such a family of compact power units be established now.

In the field of atomic energy and particularly in such outstanding developments as the SNAP application, the United States has significant technical leadership. I believe we have passed the point of debate on the existence of a real competition with the Soviets in technical areas. In this broad spectrum of competition, the impression created by the technical accomplishments of the competing systems is of vital importance. In the atomic energy field, the United States has both an opportunity and a responsibility to utilize our present technical lead to demonstrate real accomplishment, so as to substantially contribute to our international posture of competence.

Thank you.

Representative HOLIFIELD. Thank you very much, Dr. Starr. Are there any questions? If not, we thank you for a very challenging statement.

Dr. STARR. Thank you, sir.

(A letter from Dr. Starr regarding availability of uranium follows:)

ATOMICS INTERNATIONAL,
A DIVISION OF NORTH AMERICAN AVIATION, INC.,
March 8, 1960.

Senator CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy, Washington, D.C.

DEAR SENATOR ANDERSON: As you requested at the time of my 202 hearing testimony, I am writing to explain further some of the points relating to the availability of uranium resources, and in particular those areas in which you raised some questions.

You will recall that our resources study resulted in three principal conclusions: (1) that there is presently sufficient U.S. uranium at today's prices to support the nuclear industry until the year 2000, (2) that a small increase in uranium ore prices would result in enough fuel to support the industry for the next century and thta improvements in reactor technology during this time could well offset any power cost increase due to the rise in ore price, and (3) in the event that breeder reactors can be successfully developed, the potential contribution of our uranium resources is large enough to take care of our energy needs for many centuries to come.

As you pointed out, estimates of uranium and coal reserves should be made on a consistent economic basis. If we do as Putnam and others have done and consider deposits to be economically recoverable if they can be obtained for costs up to twice the going market price, we find about 260 billion tons of coal versus 2 million tons of uranium economically recoverable. If these tonnages are converted to energy equivalents using today's reactors, the results show the U.S. energy reserve of coal to be eight to nine times that of uranium.

Although it may at first seem strange that the energy equivalent of U.S. coal reserves, available at double present prices, is greater than that of uranium, two important facts should be recalled. The first of these relates to the relative contribution of fuel costs to overall power costs. When you have provided the fuel for a coal-fired plant, you have accounted for half the total power costs. In a nuclear plant the fuel cycle is only a very small percentage of the cost of the overall job of making nuclear power. Doubling the cost of coal can thus add up to 40 percent to the cost of power, whereas doubling the cost of uranium ore increases power costs perhaps only 5 percent. This factor of 8 in favor of uranium fuel becomes very important as one goes deeper into the resources at correspondingly higher prices. Furthermore, as reactor technology advances and the neutron economy of these plants improves, fuel-cycle costs will go down and counterbalance the above-mentioned effect of rising ore costs. The chances for any similar major advance in conventional fuel technology reducing the effect of increased coal costs are small.

If we now examine the resource base (defined as the total amount of uranium or coal available in the earth regardless of cost) of coal as compared to uranium, the picture changes considerably. The resource base for coal is 2 trillion short tons. The uranium resource base of 300 billion short tons is the estimated uranium content of the earth's crust under the United States for a depth of 2 miles. The energy equivalent of this resource base for coal is only double the economic reserve, as previously defined; whereas for uranium the available energy has now increased by a factor of 100,000. In other words, we have already found about one-half of all the possible coal existing in the earth, but we have located only a small fraction of the uranium. The possibilities of being able to develop and utilize large portions of this remaining resource base are much greater for uranium than for coal.

The foregoing energy equivalents for uranium are based on this fuel used in today's reactors. If breeder technology can be developed, the energy equivalent available in both the reserves and the resource base multiples from 60 to 120 times that available with present converter reactors.

There are conclusions from this uranium-resource study that apply to our Nation's reactor program planning. The availability of uranium resources in comparison to our requirements is such that we need not limit reactor designs to those which stress only long-range uranium conservation. Optimization of low power costs should be our primary goal. There is sufficient uranium available at moderate ore price increases to operate these reactors on an economic basis. Through the continuance of a broad spectrum reactor program, many advances are foreseeable in the technology of converter reactors. Consideration of these, as well as the promise of breeder reactors, indicates that before the overall resources problem becomes serious we can expect major atomic-power

developments permitting maximum utilization of the enormous potential in our uranium-resource base.

Sincerely yours,

C. STARR,
President, Atomics International Division.

Representative HOLIFIELD. Our next witness is Mr. James L. Grahl, director of the Atomic Energy Service, American Public Power Association.

STATEMENT OF JAMES L. GRAHL, DIRECTOR, ATOMIC ENERGY SERVICE, AMERICAN PUBLIC POWER ASSOCIATION

Mr. GRAHL. My name is James L. Grahl, director of the Atomic Energy Service and assistant general manager of the American Public Power Association.

The American Public Power Association, in whose behalf I am testifying, is a national trade organization representing more than 1,000 local publicly owned electric utility systems in 42 States and Puerto Rico. Headquarters of the association are at 919 18th Street NW., Washington 6, D.C.

Our association has been deeply interested in the atomic power development program since its inception and, due in large part to the interest of your committee, a number of local public power systems are participating actively in it.

Nuclear power projects are now under construction on the systems of the Consumers Public Power District of Nebraska and the city of Piqua, Ohio, under contract arrangements with the AEC, and a contract for a developmental plant on the system of the Puerto Rico Water Resources Authority recently was signed with the Commission. The Commission shortly will select a municipal or rural cooperative system on which to locate the 16,500-kilowatt pressurized water reactor authorized last year, and has invited proposals from the consumer-owned systems on the 50,000-kilowatt boiling water prototype, also authorized last year.

We greatly appreciate the interest and support of your committee in assuring the inclusion of these projects in the atomic power program, and are gratified that the Commission is moving ahead with them. Most of these projects are being undertaken under the terms of the "second round" or terms closely similar to these, and so the second-round formula appears to be workable and satisfactory.

We believe that these projects will contribute significantly to the advancement of nuclear power technology and that several of them will contribute particularly to the development of plants in the size range of 50,000 kilowatts and below, a range in which our membership has a particular interest.

Since this committee is aware of our views on the atomic power program in general, on the basis of our testimony in previous years, this statement is confined largely to comments upon the 10-year program as proposed by the Atomic Energy Commission last week.

COMMENTS ON AEC PROPOSED PROGRAM

The publication of the Commission's excellent evaluations of the civilian power reactor program is certainly most commendable. Parts

I and II in particular are highly informative and valuable documents. Part IV, the Commission's 10-year program, represents a very desirable step forward in mapping out a future program but I would like to offer the following comments on it.

1. The AEC sets a target date of 1968 for attaining marginally economic nuclear power using 300,000 kilowatt units in high-fuel-cost areas, but the program which AEC proposes does not seem geared to achieving actual demonstration of this goal by 1968. This conclusion is based upon data in part I and part II of the AEC report. For example, part I says that the pressurized water reactor is at a point where a 300,000 kilowatt plant constructed with the current technology would produce power for 9.56 mills per kilowatt-hour but that these costs "could only be achieved after the period of time required for plant construction and fuel cycle equilibrium." Allowing 1 year for design, 3 years for construction and 3 to 4 years for fuel cycle equilibrium, this indicates that a 300 megawatt PWR started now would produce 9.56 mill power by 1967–68, thus falling considerably short of the AEC goal of 7 mill power by 1968.

However, part II concludes that "with maximum telescoping of effort" a 300-megawatt PWR would be completed in 1966 which would produce power at a cost of 7.8 mills, but only after fuel cycle equilibrium is reached, 3 to 4 years thereafter. So part II indicates that the best we can do is to attain demonstration of 7.8 mill power by 1969–70, still not down to the AEC target cost of 7 mills, and 1 to 2 years beyond the AEC target date.

The above data are in respect to the pressurized water reactor, which is the most technologically advanced system in the civilian power reactor program. The gap between the 1968 goal and the achievements of AEC's proposed program presumably would be greater for the other, less well understood reactor concepts.

2. However, the AEC 1968 goal as AEC defines it seems to be not so much a specific technical goal as a state of mind. Thus, AEC says in its 10-year program statement (part IV) that "competitive nuclear power will have been achieved when utility executives can decide to build nuclear stations based on economic considerations." This is a most uncertain standard; it depends not so much on demonstrable technical achievement as on management decisions and attitudes. As defined, the AEC goal appears achievable at almost any time at the will of utility executives.

The flexibility of this standard is illustrated by AEC Chairman McCone's testimony that two California utilities are now seriously considering the construction of 300,000-kilowatt nuclear plants based upon economic considerations. If I understand AEC's definition, we apparently will achieve economic nuclear power as soon as one or both of these utilities makes a favorable decision. In this event, AEC's 1968 target could become relatively meaningless as AEC defines it.

If we were, in fact, on the threshold of economic nuclear power in 300 megawatt units, there would be a question as to the need for further Government research and development expenditures on large light water reactors. Additional cost improvements could be left to private industry and the normal motivations of the profit incentive.

In short, the AEC 1968 program objective as defined appears to be too amorphous to be meaningful. A specific objective measured in

terms of actual demonstration or other tangible evidence of technical achievement seems required.

3. As regards new reactor construction projects, the proposed AEC 10-year program reflects a general policy of "let's wait and see." With the possible exception of a 20,000-kilowatt PWR in a remote location, AEC definitely proposes now new starts beyond those already authorized. The program calls for waiting until 1963–64, after 2 or 3 years of operating experience with plants now under construction, and states that then the construction of certain additional projects "could" or "may" be started.

The proposed Commission program is more conservative and less definite than the program outlined in the valuable staff studies contained in Part II: Economic Potential and Development Program. Yet I believe that AEC has provided no detailed explanation as to why the development program suggested by the technical experts was cut back rather significantly in the Commission's 10-year program, but without an equivalent cutback in the main program objectives.

The lack of any proposed new starts is most disappointing to those of us interested in an aggressive atomic power development program. It is difficult to believe that this relatively limited approach will achieve demonstrably economic nuclear power within the next decade.

4. Our skepticism of the adequacy of the AEC program is based in part, as indicated above, on comparisons of the AEC staff studies with the AEC proposed program. This skepticism is reinforced by another consideration. AEC's optimism about early achievement of marginally economic nuclear plants relies heavily upon the light water reactors. Yet Admiral Rickover, the man primarily responsible for development of the pressurized water technology (which is the base for all light water reactors) recently stated his opinion that the achievement of economic nuclear power would take at least 10 more years and perhaps 20. This observation seems at considerable variance with AEC's judgment of a relatively high probability that light water cooled reactors in the reasonably near future can achieve competitive power in the high fuel cost areas of the United States where large single units are practical.

5. The AEC optimism about the adequacy of the present reactor construction program apparently is based upon extrapolations of the estimated nuclear "power costs developed in the staff studies in parts I and II. However, aside from Shippingport, these figures rest upon very little power reactor operating experience. In the case of several concepts, they rest upon none at all. While the capital-cost figures doubtless are based upon actual construction experience to date, fuel and operating cost estimates are quite conjectural.

Furthermore, virtually every power reactor project under construction has experienced cost or technical problems. Yet the AEC program statement (pt. IV) makes no mention of these difficulties. As a matter of fact, it refers in one place to "the large Dresden plant now in initial operation," although this plant is not in initial operation and has been encountering difficulties in even going critical.

The above are further reasons for wondering whether the Commission's present optimism is justified.

Representative HOLIFIELD. Mr. Grahl, we have been accustomed in this committee to optimistic statements for the past 10 years in regard to the reactor program. So, this is not new at all. We have had many optimistic conjectures as to how many millions of watts would be on the line by certain dates, and how close we were to economic power, and all these sorts of things. This is part of the rosy-glass technique that has been in evidence for many years in the AEC.

Mr. GRAHL. Yes, sir.

Representative HOLIFIELD. Please continue.

Mr. GRAHL. 6. The AEC program makes no specific provision for additional projects aimed at developing economic small plants; that is, in the 50,000-kilowatt range and below. This size range is of particular interest to many of the local publicly owned utilities which are members of the association, and the lack of additional projects is severely disappointing. Last year, at the urging of this association and the National Rural Electric Cooperative Association, the Commission made some preliminary studies and set up what we understood would be a systematic small plant development program. We were highly gratified at this and at the fact that AEC recommended, and your committee and the Congress approved, an additional small-plant, second-round project last year. This, together with the Piqua and Elk River projects, provided a base for the program.

However, a series of small plants of each of the selected types will be required if this effort is to be effective. In its study last year for AEC, the General Nuclear Engineering Corp. concluded that a direct-cycle, boiling-water reactor coupled with an oil-fired superheater "could achieve the objective of immediately establishing a new low in power cost from small nuclear powerplants." Last August, the Commission itself seriously considered adding such a project to the small-plant program.

For AEC now to propose no new starts during the next 2 to 4 years means further delays, and the AEC 10-year program therefore seems seriously inadequate as far as plants of 50,000 kilowatts and below are concerned.

PROGRAM RECOMMENDATIONS

Based upon the foregoing considerations, we offer the following recommendations:

1. That more tangible and definite goals be adopted for the atomic power program than AEC has proposed and that, to supplement the projects sponsored by utilities under the AEC partnership program, a strong Federal program of developmental power reactor construction be undertaken along the lines of the Gore bill, S. 683.

The brilliant success of the Shippingport reactor program suggests that such a Federal program should include developmental plants designed and operated primarily to solve technical problems, and backed up by a large and competent research and development laboratory. As we have testified previously, we do not regard this bill as public-power legislation, inasmuch as such developmental plants would make comparatively little power available for public distribution. In fact, most of this power would probably be used by AEC itself.

(See also letter dated December 16, 1959, to Chairman Anderson from James L. Grahl, in app. 5, p. 641.)

2. That the small plant development program which presumably was established as a definite effort last year be continued on a systematic basis, and that Congress authorize this year at least one more second-round project in the small-plant size range.

3. That Congress authorize the conversion to a dual-purpose plant of the large convertible reactor now under construction at Hanford. Such conversion would make constructive use of the reactor heat to create a power capacity of at least 700,000 kilowatts, equivalent to more than one Bonneville Dam, instead of wasting this huge amount of energy. This recommendation is based upon the General Electric Co.'s finding that a dual-purpose plant would be economically justifiable and result in a lower net cost of plutonium to the Government.

4. That every reasonable effort be made to make full use of the heat energy from the new 150,000-kilowatt core to be installed in the Shippingport reactor. For AEC to spend several million dollars in order to waste steam equivalent to 50,000 electrical kilowatts does not seem sensible. The addition of a 50,000-kilowatt turbine generator not only would make use of the additional energy from the new core, but also would permit further development and testing on the steam turbine end of the plant. The latter would appear desirable, in view of the serious difficulties encountered to date with the turbine equipment.

AEC is already investing a substantial sum on equipment to dump steam equivalent to about 20,000 electrical kilowatts at the experimental boiling-water reactor at Argonne National Laboratory, and it would be most regrettable to repeat this policy on a large scale at this country's primary developmental power reactor facility.

5. That the national laboratories continue to play a strong role in civilian power reactor development. The Nation should continue to receive the benefits of fully effective use of these uniquely valuable facilities. We recognize, of course, the need for and desirability of a flourishing private industrial capability in this field. However, this should not, and need not, be achieved at the price of reducing the effectiveness of the laboratory organizations which in large part have created the science and technology of nuclear reactors.

Attached to this statement are copies of several resolutions on atomic power development which were adopted by our membership at the association's 1959 annual convention in Seattle, Wash. I respectfully request that these be made a part of the record.

On behalf of our association, I should like to express our appreciation for this opportunity to present our comments on the atomic power program.

(The resolutions referred to follow:)

[Resolutions on atomic power issues adopted by the membership of the American Public Power Association at its national convention, May 28, 1959, Seattle, Wash.]

SMALL ATOMIC POWERPLANTS

Whereas the American Public Power Association repeatedly has emphasized the need, in the interests of the consumers of the several thousand local publicly owned and cooperatively owned electric systems in the United States, for developing economically practical atomic powerplants in the range of 5,000 to 50,000 kilowatts of electrical capacity; and

Whereas atomic powerplants in this size range also are important for use in the underdeveloped countries of the free world; and

Whereas the Atomic Energy Commission has approved in principle contract arrangements with the municipal electric system of Piqua, Ohio, a member of this association, and is constructing a power reactor on the system of the Rural Cooperative Power Association of Elk River, Minn.; and

Whereas the Commission this year announced its intention to launch a specific program to develop commercially practical small civilian nuclear powerplants and has requested congressional approval of one developmental project for this purpose; and

Whereas an effective program and the timely achievement of economic small plants require a larger program for the construction and operation of developmental projects: Now, therefore, be it

Resolved, That the association commends AEC's favorable action on a small-plant development program, urges that the Piqua project be undertaken as soon as possible, and recommends that additional small-plant projects be authorized by the Congress and initiated promptly in order to establish an adequate and effective program for small nuclear plant development.

HANFORD DUAL-PURPOSE PLANT

Whereas the U.S. Congress has authorized the construction by the Atomic Energy Commission of a new plutonium production reactor at Hanford, Wash., capable of conversion to power production; and

Whereas studies by the General Electric Co., the operating contractor for the Hanford works, show that a dual-purpose plant would produce plutonium for the Government at the lowest cost and that the power excess to Hanford's needs could be integrated with the system of the Bonneville Power Administration; and

Whereas such a plant would contribute importantly to the advancement of atomic power technology; and

Whereas there are no presently planned or existing atomic powerplants in the Pacific Northwest; and

Whereas the location of the Hanford convertible reactor would not interfere with the later construction of the proposed three-quarter million kilowatt Ben Franklin Dam: Now, therefore, be it

Resolved, That the American Public Power Association urges the early authorization and installation of power-producing features for the Hanford convertible reactor in order to achieve the dual benefits of low cost plutonium and power production; and be it further

Resolved, That the dual-purpose plant be utilized fully as an atomic powerplant training and information center for the Pacific Northwest.

NUCLEAR POWER DEVELOPMENT PROGRAM

Whereas our fossil fuel reserves are exhaustible and nuclear power must be developed with vigor and determination to provide the American people with an ever-increasing supply of low-cost electric power; and

Whereas recognized U.S. international responsibilities also require a fully effective atomic power development program; and

Whereas the experience of the past 4 years has demonstrated conclusively the inadequacy of the efforts of the private power companies to build the developmental atomic powerplants required for a strong and purposeful U.S. atomic power program; and

Whereas this experience has fully confirmed the position consistently taken by this association that a substantial number of additional Federal full-scale plants should be undertaken promptly in order to strengthen and accelerate the U.S. atomic power program: Now, therefore, be it

Resolved, That the American Public Power Association urges that the U.S. Government adopt a clear and positive policy and program for developing atomic power and establish objectives for an accelerated effort; and be it further

Resolved, That the association urges the Government to undertake in the public interest the construction of atomic powerplants of representative sizes and types, both large and small, in addition to the projects underway or proposed under the present demonstration program.

Representative HOLIFIELD. Thank you, Mr. Grahl, for your comments. Are there any questions? If not, we will excuse you.

Mr. GRAHL. Thank you.

Representative HOLIFIELD. We will ask Mr. J. D. Rauth, of the Martin Co., to come forward.

STATEMENT OF J. DONALD RAUTH, VICE PRESIDENT, THE MARTIN CO., GENERAL MANAGER, NUCLEAR DIVISION

Mr. RAUTH. Mr. Chairman, my name is J. D. Rauth. I am a vice president of the Martin Co. and general manager of Martin's Nuclear Division.

Martin's efforts in the nuclear field include the manufacture of fuel elements, the design and production of complete reactor systems, and the relatively new area of isotopic power. In order to save the time of the committee, I would like to ask permission of the chairman to submit a letter for the record containing more detailed information on our current programs (p. 344). I feel that this background may be helpful in considering my remarks today on two specific areas of the industry. These are the fields of military ground power and of isotopic power.

On the subject of military ground-based power, I have two observations to make. The first stems from the fact that economic factors have a far greater bearing on the use of nuclear power for military ground stations than they do on nuclear propulsion—whether it be propulsion of submarines, aircraft, or rockets. In the fiield of propulsion, there are certain jobs which other systems simply cannot do. If we want to do these jobs, we have no choice but to use nuclear power. When we talk about supplying heat and electricity to meet ground-based military requirements, however, we must recognize that these tasks can be handled using other fuels.

During the past 5 years, Martin has invested heavily in facilities, equipment, and personnel devoted to reactor systems for military ground use. In several of our recent bids we have expressed a willingness to make further investments of our own capital in facilities which would be of special value and which would also help us to keep pace with future technological development. These investments have been made and are being made with the conviction that ground-based nuclear power will play an important role in future military planning and that nuclear power can compete economically with conventional power in remote areas. Initial costs of nuclear installations are higher, but a fair economic comparison must also consider the cost of generating power over the expected life of the plant. Since military budgets are authorized annually, it is often hard to argue for long-term savings. Also, since nuclear powerplants are not linked directly to specific operational missions, as are missiles and submarines, they are not likely to be treated with the same degree of urgency. Nevertheless, we are convinced of the economic soundness of this solution to remote military power needs; and we feel that the experience gained from further operational tests should produce an expansion of orders for small nuclear powerplants. Our PM 1 plant for the AEC and the Air Force is a major step in packaged power.

My second observation on ground-based military power reactors concerns contract bids. We have already had occasion to make a fixed-price bid on one small military power reactor system, and we

expect to do so again where the system has been firmly and clearly established. Once the developmental stage in a given system is past, it is generally possible to proceed on a fixed-price basis with guaranteed performance.

Representative HOSMER. At this point before you go into the radioisotopes, I would like to ask you about the packaging of these military reactors. It seems to me that they are going one place and they are going to stay there and they are not going to be rotated around at various bases overseas, the packaging as far as I understand it seems to be to a greater degree than is necessary to facilitate putting atomic reactors at a remote base. Am I wrong in that impression or are there factors in it that I don't understand?

Mr. RAUTH. Our particular system, which is the PM 1, was built to be air shippable. This feature, I am advised, is important when you are thinking of the Arctic installations. If you have to haul this unit over the Arctic ice, the best you can do is a few miles a day. So if the system is in fact air portable, then you are able to actually go into the area, bring in your aircraft, and install it at the site.

Representative HOSMER. Perhaps the packaging term is a wrong term. It is a reactor that is broken down into pieces of size and weight that are air shippable?

Mr. RAUTH. That is right.

Representative HOSMER. And not necessarily what we would regard as a do-it-yourself, move-it-yourself, reactor, is that right?

Mr. RAUTH. That is right, sir.

Representative HOSMER. Thank you.

Mr. RAUTH. The oldest continuing contracts in our nuclear division are those from the Aircraft Reactors Branch of the AEC's Division of Reactor Development and are in the area of isotopic power. From this work, the isotopic fueled SNAP III thermoelectric generator was developed. To me the successful operation of the SNAP III unit opened up a new era. The ability to operate continuously for years without refueling or servicing makes such a device unique. In fact, there are some applications in which isotopic power seems to provide the only solution; and even from an economic standpoint it can compete in many areas with more conventional sources. Discussions with the military services have produced much interest. We are now designing and building for the Office of Isotopes Development of the AEC a strontium 90 direct conversion power source for an integrated design of an automatic weather station. This unit would take advantage of the long half life of the isotope and the direct conversion features. This unit was referred to by the AEC before you last week. A model of this station, prepared for the Office of Isotopes Development of the AEC, is here today. I understand that you have expressed an interest in seeing it.

The opportunity to exploit the usefulness of isotopic-powered devices remains stunted, however. The basic roadblock is the unavailability of suitable amounts of specific isotopes. For your reference, the first SNAP III generator used about 1,700 curies of radioactivity. The weather station, mentioned earlier, will use about 20,000 curies. A single 100-watt generator designed for the AEC to use strontium 90 will require 300,000 curies of activity. Interest in applications involving isotopic power is often chilled when we

answer—how much, and how soon. The raw materials, fission wastes, exist and the needs are developing, but we face a lack of supply. I am speaking of the need for megacurie amounts of activity.

Pilot plant operations in the separation and purification of useful radioisotopes are now underway in AEC facilities. These have been successful, although cost has naturally been high. The AEC has expressed interest on several occasions in facilities for quantity production, and it was in response to this that the Martin Co. and the Air Reduction Co. began joint investigations over a year ago. AirCo is a company with an international reputation in the chemical-processing field.

Senior management and technical personnel of Martin and AirCo have explored the feasibility of a privately financed isotope separation facility which could start the sort of production we jointly felt was needed in this field. The AEC has been advised of our efforts and has given excellent cooperation.

Investigations by Martin and AirCo are continuing, aided by outside consultation; but enough progress has been made so that we can report several interesting and favorable indications.

Right now, pure strontium 90 in the form of oxide costs between $3.50 and $5 a curie, depending on the amount ordered. Our investigations show that by putting one major facility on stream in the production of this single radioisotope, its cost in megacurie quantities could be reduced to one-tenth of current costs.

Naturally, the construction and operation of a privately owned separation plant would require close Government cooperation, including permission to locate the plant near a producing source of fission waste. The output of the new facility would, of course, be available to any industrial firm, scientific organization or Government agency holding a proper AEC license. I feel that we are speaking of an expenditure of from $10 to $12 million.

Based on the existing potential of isotopic power, we feel that it is in order to establish an adequately financed, long-range program for the development of isotopic applications. A statement of these objectives would give industry a basis on which to plan. Under these conditions we feel that it is feasible to consider the financing of isotope separation facility by private investment. Here I am able to say that we at Martin have authorized upward of $850,000 to build a new nuclear laboratory to support our feelings with regard to isotopic power. Application for a license has been made.

I believe that a healthy, well-rounded national program for nuclear energy must include the development of the important field of isotopic power. And as experience in numerous other scientific and technological areas has shown, the beneficial effects will be multiplied by the stimulation of research and development in associated fields as well. From our own experience, I can say that this has already been the case in the fields of direct conversion and, more recently, in aspects of the basic problems of radioactive fuel forms and waste storage.

In conclusion, I would simply like to endorse the efforts of the AEC to develop a long-range program for large scale applications of radioisotopes and to urge this committee to further this work as a matter of national importance.

Representative HOLIFIELD. Thank you, Mr. Rauth. Are there any questions?

Representative HOSMER. This $850,000 laboratory that Martin is going to build, I can't understand from your statement whether that is an isotope separation facility or something entirely different.

Mr. RAUTH. No, it is not. It will contain four hot cells to handle the building part of a job that we have in isotopic power.

Representative HOSMER. It doesn't have anything to do with isotopic separation facilities?

Mr. RAUTH. That is right.

Representative HOSMER. You are saying in this connection Martin will build.

Mr. RAUTH. That is right. In the establishment of a national development program I feel that other facilities will also have to be built to support this idea. What I am saying is that we are actually doing that now.

Representative HOSMER. That is all.

Representative HOLIFIELD. Mr. Toll has some questions.

Mr. TOLL. Mr. Rauth, isn't the AEC producing huge quantities of strontium 90 at Hanford and Savannah River? Don't they separate those waste products out in that way?

Mr. RAUTH. No, they don't, or at least I don't think they do. Our own supply has been from Oak Ridge, and they do not have big facilities down there for handling isotopes in the volume I am talking about.

Mr. TOLL. During the waste disposal hearings last year the AEC testified that strontium 90 and cesium 137 were their most long-lived isotopes that they were worried about, and they were putting huge quantities of these isotopes in stainless steel tanks underground. Do you have any figures on the number of curies of strontium 90 that is currently stored underground at Hanford?

Mr. RAUTH. No, I don't. I am not aware that they are extracting strontium 90 from the fission waste. I am speaking of an extraction of strontium 90 and various other isotopes from the fission wastes that are at Hanford, for example.

Mr. TOLL. I realize your problem is separating out the strontium 90 from all the rest. But there is a large amount of this stuff available now to be separated if you or somebody else wants to do it.

Mr. RAUTH. That is true.

Representative HOLIFIELD. Are you suggesting that the $10 or $12 million plant for separation should be built by the Government or built by private industry?

Mr. RAUTH. By us, by industry, I mean.

Representative HOLIFIELD. Are there any roadblocks in the way as far as licensing is concerned?

Mr. RAUTH. No, I don't think so. We have already been able to build up the ability to generate power. We have been able to speak to the Air Force, Navy, and other agencies, which apparently would be able to use it, and over the past year we have been able to actually build up a lot of interest. But we always seem to come to a bit of a halt when they ask: Is it available? Are the isotopes available? Because I can see need for—and they go ahead and outline their bulk uses. We at that particular spot have to say that the isotopes are not

available at this time, but they are in storage, they are in waste, and all that you have to do is to build an extraction plant. We are interested in this installation ourselves, and we have studied it in detail.

Representative HOLIFIELD. Have you made studies on the problem of storing the waste from the separation?

Mr. RAUTH. Yes, sir; we have.

Representative HOLIFIELD. And the cost problems involved in storing the leftover waste materials?

Mr. RAUTH. There are those.

Representative HOLIFIELD. Is it planned to put it right back into the Government storage tanks?

Mr. RAUTH. We have not gotten into that particular detail yet. But it is interesting to see that in our studies for the AEC we have been able to do some work on strontium titanate. It happens that this is a very stable form of strontium. It is awfully early to say, but this form could also be used for storing strontium, as an example. It is very stable, we feel.

Representative DURHAM. Mr. Rauth, what is your background? Are you a chemist or physicist?

Mr. RAUTH. No, sir; I am an engineer.

Representative DURHAM. You brought something up here that is very interesting. I don't believe anybody else has been in this field of work as far as I know to the present time.

Mr. RAUTH. It is actually new. It is very new.

Representative DURHAM. In other words, you people are the first who have brought up this idea of producing power from isotopes.

Mr. RAUTH. Yes, sir.

Representative DURHAM. And actually put it in operation?

Mr. RAUTH. Yes, sir.

Representative DURHAM. On the use and the cost, I notice you state on the third page that SNAP generally uses 1,700 curies of radioactivity. There was a station mentioned earlier that used 20,000 curies. Over what period of time is that use?

Mr. RAUTH. This is the charge that we would put into the particular unit.

Representative DURHAM. That is what I thought. But from reading here, you could interpret it as being used up. That is not the true set of facts.

Mr. RAUTH. The generator we are building that would use strontium 90 would have a 28-year half life of the isotope. We would aim to extract the heat from it for whatever portion of that life is feasible.

Representative DURHAM. And the use of the generating power would depend on the life of the radioisotope.

Mr. RAUTH. That is right.

Representative HOLIFIELD. Thank you, sir.

Mr. RAUTH. Are you interested in the model at this time?

Representative HOLIFIELD. Yes. Would you put it on the table and show it?

Mr. RAUTH. Let me introduce Dr. J. G. Morse, from our organization, who will explain it.

Dr. MORSE. Gentlemen, this is a half-scale model of an automatic weather station. It is powered by 20,000 curies of strontium 90 as the heat source. The strontium is contained in pellets as the titanate

which, as Mr. Rauth has indicated, has been demonstrated to be an extremely safe and reliable fuel form. The titanate is virtually insoluble in fresh water, and its solubility in sea water as studied by tracer techniques is shown to be in the range of 10 parts per billion, reaching equilibrium in about 39 years.

This heat source is clad with a material that has been studied by the Navy for about 13 years. This is hastelloy C, which corrodes at the rate of one ten-thousandth of an inch per year. If this entire unit were to fall into water it would take 500 years to corroded own to the heat source, which in itself is insoluble in water. Of course, in 500 years we would have gone through more than 20 half lives of strontium 90.

Representative DURHAM. Would it operate under those conditions?

Dr. MORSE. Yes. This unit is designed for land application, but the powerplant can be designed for sea application to meet some very important military needs. The powerplant actually is a trickle charger for a battery which is the primary source of power. The unit requires 430-watt minutes for operation. This weather station has a master timer which puts it on the air every 3 hours. It puts its call signal on the air, and a sequencer measures such basic parameters as temperature, wind velocity, and barometric pressure. This is transmitted over two frequencies in a period of about 17 seconds.

Representative HOLIFIELD. What is the range of transmission?

Dr. MORSE. By design the range of this transmitter was 300 miles. This was a selection by the Weather Bureau.

Representative HOLIFIELD. Would this type of thing be useful in unmanned seismographic stations for the detection of bomb test vibrations?

Dr. MORSE. Yes, it very definitely would.

Representative DURHAM. Wouldn't the life depend on the batteries?

Dr. MORSE. Yes, the lifetime depends on the battery, but you are always charging the battery. The unit can be designed to produce a continuous amount of power, depending on the continuous type of operation.

Representative HOLIFIELD. You don't have to have a separate battery?

Dr. MORSE. No, we don't. In this particular case it was felt that because of the present-day cost of strontium 90 it would be appropriate to design this as small as possible, so a 5-watt unit was selected under Dr. Aebersold's program.

Representative HOLIFIELD. And a 5-watt unit will transmit 300 miles?

Dr. MORSE. Yes. Actually we are using 430-watt minutes for the entire operation of the station, which means that for 10 minutes out of each 3-hour period it measures the wind velocity, takes readings, takes the average, and transmits all of the data.

Representative DURHAM. Who has indicated an interest in this?

Dr. MORSE. The Weather Bureau has expressed an interest in this. The powerplant is being built for the Weather Bureau and they will plan to use it in such an application.

Representative DURHAM. That is a scale model. How large would it be?

Dr. MORSE. This is half scale. Now, depending on the isotope, the unit could be larger or smaller. Using those isotopes with higher specific powers we can reduce the size of the powerplant proportionately.

Representative HOLIFIELD. This would transmit for approximately 28 years?

Dr. MORSE. This was designed for 2 years, not because of the life of the battery or of the isotope, but because of the electronic components. This is giving impetus for the development of electronic components to operate over a long period of time.

Representative HOSMER. How much does it cost?

Dr. MORSE. The powerplant will cost $50,000 for the first unit. This will not include the cost of the radioisotope. However, we feel that in production this powerplant, including the radioisotope, would cost about $5,000 to $7,000, that is, producing several hundred of these.

Representative DURHAM. Suppose you had a large order from the services for 500 of them or 200 of them, would the strontium 90 be available to you?

Dr. MORSE. No. Oak Ridge has a capability of 300,000 curies per year. This unit requires 20,000 curies.

Mr. TOLL. Is Oak Ridge the only source?

Mr. MORSE. Yes. This is why we have looked into the isotope separation process.

Representative DURHAM. That is why you are primarily interested in building this plant to produce strontium out of radioisotopes?

Dr. MORSE. Yes. The Navy in particular has expressed a strong interest for use of the plant under sea. In undersea use we would use a smaller amount of radioisotopes because of the greater efficiency in dissipating heat. We would actually get the same amount of power for a smaller quantity of radioisotope.

Mr. RAUTH. There are some very interesting applications for this device.

Representative DURHAM. It sounds more sensible than going up to the moon in trying to find out the weather.

Dr. MORSE. We are working on this, too.

Representative DURHAM. This makes better sense to me because with 150 or 200 of them in proper places, you could forget about the moon.

Dr. MORSE. The Weather Bureau has told us there are about 800 places on the earth from which they would like to receive weather data, but there is no means of getting it today.

Representative DURHAM. That is very interesting.

Representative HOLIFIELD. May I ask if Dr. Aebersold is in the house? Dr. Aebersold, could you respond to a question of what difficulty you would have at Oak Ridge in making another step in the separation procedure of this material? Would it run into the nature of a $10 or $12 million plant?

Dr. AEBERSOLD. The Oak Ridge plant is merely a pilot plant, where we are working out separation procedures to obtain purified fission products, such as strontium 90, from various plutonium process wastes. The wastes at Hanford are not in a form that is easy to extract the strontium from, because they are neutralized, and put in storage tanks in such a form that several chemicals have been added. If you pay to pump the wastes back, it is very uneconomical. The only way to get

strontium 90 economically would be on the main stream of the plutonium process while you are removing plutonium and uranium so that you could at the same time take out the strontium. We have some work underway that shows this could possibly be done by solvent extraction. You might be able to remove the strontium in a similar way to plutonium. If one makes such a breakthrough, then strontium 90 would be cheap. To get large quantities of it would require use of Hanford or Savannah facilities. We would have to modify some of the plutonium extraction plants to do this. I think the fastest approach would be through Hanford by modifying one of the old bismuth phosphate process lines that is now out of date. It would take about 2 years. I can't give you the exact figures in cost, but it would be less than to build a complete new plant. Perhaps the first stage should be to go to a modified existing AEC facility as the cheapest approach. We should also do process development to find the cheapest way of getting strontium 90 in the longer range, so that private enterprise would be able to take that second step of large-scale commercial production. They may, of course, wish to take the first step.

Representative DURHAM. I don't know how many tankfuls you have out there, and I forget how much they hold.

Representative HOLIFIELD. 50 million gallons.

Representative DURHAM. Now we are destroying something we need.

Dr. AEBERSOLD. I am afraid those wastes are in very poor shape for chemical extraction of pure fission products, and even the cost of pumping them up would be very serious. Taking the strontium and cesium out would cut down somewhat the heat generation in these wastes. The boiling would not be so serious. I think it would reduce somewhat the cost of the waste disposal. It will not however eliminate the cost of waste disposal, because you still have other isotopes to dispose of.

Mr. TOLL. Don't you also have strontium 90 in most of your spent fuel elements from civilian power reactors?

Dr. AEBERSOLD. Yes, sir. I completely overlooked discussing that source. Of course, the fuel processing for power reactors will in the future be a large source of strontium 90. When there is private processing of fuel or even Government processing of fuel from civilian power reactors, there will be a continuous supply of strontium 90 and cesium 137. I think both of these isotopes have a lot of uses, and we are undertaking a program to develop uses for large quantities.

Mr. TOLL. There has been some talk of a private fuel reprocessing program for civilian reprocessing of fuel elements.

Dr. AEBERSOLD. Yes. One of the objectives of the isotopes development program is to develop isotope uses which will stimulate future private production.

Mr. RAUTH. I think we ought to add here that the bulk we are speaking of, and the particular needs, you will be years before you will be able to get that from the industry. I mean there are big amounts. We are actually speaking of using big amounts and we think we see some needs. The only source at the present time would be possibly Hanford.

Representative HOLIFIELD. The weapon production plants.

Mr. RAUTH. Yes.

Dr. AEBERSOLD. With respect to the remote weather station you may be interested in the use of the 95 watts of heat that are not used for electrical production. There is only 5 percent conversion of heat to electricity. The 95 watts of heat, however, is very useful for heating the weather station. So for any use in a cold zone, in the Arctic, on mountain tops or in undersea applications, the other heat is not wasted.

Representative HOLIFIELD. Thank you. Thank you very much for your presentation. The model is very interesting.

Mr. RAUTH. Thank you, sir.

Representative HOLIFIELD. Mr. Brownlow, you can see we are running about an hour behind, and some of the members have appointments in their offices. I might give you an opportunity to make a choice here. Would you like to summarize this and put the whole statement in the record tonight, or would you like to come back tomorrow and be the leadoff witness?

Mr. BROWNLOW. I think I would prefer to come back tomorrow if that would be all right with you.

Representative HOLIFIELD. Under those circumstances, we will put you on as the first witness in the afternoon. I am sorry we did not get to you today.

We will meet tomorrow afternoon at 2 o'clock. The meeting is adjourned.

(The letter by J. Donald Rauth, dated March 31, 1960, referred to on p. 336, contained the following material:)

SUPPLEMENTARY INFORMATION ON CURRENT AREAS OF WORK

The Martin Co. has been active in the nuclear industry since 1954. At present, its major efforts embrace the manufacture of fuel elements, the design and production of reactor systems, and the development of energy sources using the decay heat of certain radioisotopes—the field usually referred to as "isotopic power." It is also pursuing a broad program of contractual and company-sponsored research and development in connection with these project areas.

In the reactor field, Martin is the prime contractor for PM–1, a portable nuclear powerplant to be installed next year at an Air Force station near Sundance, Wyo. PM–1 is a pressurized water system in which local boiling is permitted and highly enriched fuel is utilized. The plant will provide about 1,000 electrical kilowatts plus heat for Air Force buildings. The final design of the system is complete, and zero power tests of the PM–1 core began March 17, when criticality was first achieved by a basic fuel element assembly.

Since its conception, PM–1 has been intended as an optimized system for remote applications. Significant achievements have been made in assuring air-transportability by reducing overall weight and the number of individual "packages" involved. Ability to operate under extreme temperature conditions has been another major design consideration.

Martin is also at work now—under contract with the U.S. Atomic Energy Commission—on the development of a completely new reactor concept—the so-called liquid fluidized bed reactor, or LFBR. The first critical test of an LFBR core, using pelletized fuel of very low enrichment, will be carried out later this year. In this system, criticality is to be achieved by regulating the flow of liquid moderator upward through the pellet bed. If the concept proves technically feasible, it would be applicable to very large power stations and appears to offer distinct economic advantages. Commercial application, however, must await the successful outcome of efforts in several R. & D. areas.

Martin's interest in the LFBR concept dates back to 1955 and stems from a long-term policy of concentrating energies in developmental work on the one or two key items within a system which seem to offer the greatest potential for reducing costs or advancing the state of the art. This same policy has led the company to focus a major part of its efforts on the areas of metallurgy and material development, and to develop the capability of producing the various types of fuel elements used in systems with which it is associated. Martin is convinced, as are many others, that the most immediate and significant ad-

vances in reactor economics will come through improvements in the fuel cycle.

Besides manufacturing the stainless steel tubular fuel elements for PM–1, Martin has produced or is building elements of various types on a subcontract basis. For example, it produced the aluminum elements for the Spert–2 experiments in Idaho, and it is now building the first core of ceramic rod elements for the Elk River reactor. The company has also developed an inexpensive technique for the manufacture of foil-type elements; and, under contract with the AEC, Martin-Nuclear has fabricated a large number of such elements for use in a series of critical experiments in its own privately owned facility as part of the Army nuclear power program.

Studies of the materials, control and shielding problems associated with extremely compact reactors, although being carried out now as company-sponsored rather than contractual programs, are also an important segment of the development pattern. Martin has completed the detailed preliminary design of a nuclear rocket system, and the cooperative efforts of several of the company's divisions are being expanded in a joint program which is expected to lead to the engineering, manufacture, and test of nuclear-powered flight propulsion systems.

The oldest continuing contracts in Martin's Nuclear Division are in the area of isotopic power. These include programs in the SNAP (system of nuclear auxiliary power) series, as well as efforts oriented toward various civilian uses.

Although much has been written about the special value of isotopic power for space missions, its long-range importance will probably lie in land and sea uses. A typical application is a remote, automatic weather station, which is depicted in an accompanying illustration. A model of this system was displayed to the committee during the hearings. A diagram of the 5-watt generator to power it and a summary of design are also submitted for the committee's consideration.

In many cases, but not all, the efforts of Martin-Nuclear are an integral part of companywide programs. This is perhaps most apparent in the case of flight propulsion, but the same principle also applies to isotopic power and small reactor powerplants. Martin's work on SNAP is part of a broad approach to the field of auxiliary power which includes development of solar energy, fuel cells, and long-lived battery systems. Similarly, reactors of moderate dimensions promise great advantages in the ground-support systems which are playing an ever-increasing role in our Nation's missile network.

On the other hand, the best interests of Martin-Nuclear dictate that it cannot be completely bound by tradition, and the division will continue to direct and extend its energies toward whatever areas of the nuclear field seem most appropriate for its capabilities.

(Thereupon at 4:40 p.m., Tuesday, February 23, 1960, a recess was taken until Wednesday, February 24, 1960, at 2 p.m.)

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DEVELOPMENT, GROWTH, AND STATE OF THE ATOMIC ENERGY INDUSTRY

WEDNESDAY, FEBRUARY 24, 1960

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
Washington, D.C.

The committee met, pursuant to recess, at 2 p.m. in room P–63, the Capitol, Senator Clinton P. Anderson (chairman of the Joint Committee) presiding.

Present: Senator Anderson; Representatives Durham, Holifield, Price, Hosmer, and Bates.

Also present: James T. Ramey, executive director; John T. Conway, assistant director, and George F. Murphy, Jr., professional staff member.

Chairman ANDERSON. The committee will be in order.

This afternoon the Joint Committee is meeting to receive testimony from witnesses from industry on the development, growth, and state of the atomic energy industry.

Our first witness this afternoon is Mr. J. A. Brownlow, Metal Trades Department of the AFL–CIO.

We are glad to have you with us.

STATEMENT OF J. A. BROWNLOW, METAL TRADES DEPARTMENT, AFL–CIO

Mr. BROWNLOW. Thank you, Mr. Chairman.

Mr. Chairman and members of the committee, my name is James A. Brownlow and I am president of the Metal Trades Department of the American Federation of Labor and Congress of Industrial Organizations, with offices located at 815 16th Street NW., Washington, D.C.

I deeply appreciate this opportunity to appear before the committee and make some brief observations and comments dealing specifically with certain of the Atomic Energy Commisison's contract policies as they affect our membership employed in the Commission's installations throughout the United States.

The metal trades department was chartered by the American Federation of Labor in 1908. It is composed of 20 affiliated international unions. Almost every one of these affiliated unions has membership employed in plants of the Atomic Energy Commission.

I know that the members of this committee are aware of the deep interest of the metal trades department, its chartered atomic metal trades councils, and its affiliated international unions in representing the production and maintenance workers employed at the major AEC installations.

We estimate that over two-thirds of such organized workers in these installations presently are represented through our department and its atomic metal trades councils or directly through our affiliated international unions.

Included among the prime AEC installations where our atomic metal trades councils hold exclusive bargaining rights and have signed collective-bargaining agreements with the operating companies are the Hanford Works; the Oak Ridge National Laboratory, X–10; the Fabrication and Development Facility, Y–12, at Oak Ridge; the Sandia Laboratory at Albuquerque; the Argonne National Laboratory; the Feed Materials Processing Center at Fernald, Ohio; the Rocky Flats Plant near Denver, Colo.; the Pantex Plant at Amarillo, Tex., and several units at the National Reactor Testing Station at Arco, Idaho.

Among the various other installations where one or more of our metal trades department affiliated international unions hold bargaining rights are such projects as the South Albuquerque Works operated by ACF Industries; the Kansas City plant, operated by Bendix Aviation; the Burlington plant operated by Mason Hanger-Silas Mason; the Shippingport project in Pennsylvania; the radiation laboratory and its Livermore extension operated by the University of California; the Zia Co. servicing Los Alamos; and the aircraft nuclear propulsion project at East Hartford, Conn.

I would call to your attention, gentlemen of the committee, that every one of these are contractors in the true sense of the word.

The metal trade department, its chartered atomic metal trades councils, and its affiliated international unions are concerned about the constant whittling away of our certified bargaining units and the resultant continual narrowing of the scope of our collective-bargaining agreements with the prime operating companies at the major AEC installations.

Classifications of work and whole functions are being carved out from the operations previously performed by the operating companies where we hold certification and farmed out to a wide variety of industrial concerns, either by subcontract from the operating contractor or by the direct action of the Commission.

Complaints to us by our affiliates and our atomic metal trades councils against the shrinking of their bargaining rights due to the farming out of work which they normally and historically have been performing have been growing in recent years.

At Oak Ridge, for example, it was estimated by our council some time ago that work which had been subcontracted and which was of a type previously performed within the scope of our bargaining unit involved a total of some 300 jobs of varying duration which would otherwise have been performed by workers in our certified bargaining units.

The wage rates and working conditions which have been built up over many years of collective bargaining with the operating companies are comparable with those in private industrial establishments.

It is inequitable and manifestly unfair for the AEC not to recognize its responsibilities to the production and maintenance workers at its installations, who have struggled against unusual and heavy odds to

achieve a measure of job security and protection through their collective bargaining agreements.

In addition, seniority, retirement plans, hospitalization, and other benefits have been successfully negotiated with the companies which will not be absorbed by any outside contractor. The outside contractor will not enter into conditions embracing those in atomic energy plants because of the danger of being compelled to do the same for his other operations.

We could accumulate and present evidence to show that work from our certified bargaining units at AEC installations which has normally been performed under our working agreements with the operating companies, sometimes is farmed out to nonunion, unorganized, low-wage establishments.

Such actions, presumably taken in the interest of economy and to strengthen free competition in private enterprise, is done at the expense of the job security and the morale of our members employed at the AEC installations.

May I make this statement as emphatic as I can. I do not oppose, neither do any of my associates or the international unions affiliated with the metal trades department oppose, a contract system. We raise no voice of objection whatever against the contracting out of the construction work or any other work which AEC or even the prime contractor may see fit to do, except that where he replaces men who who are presently certified to perform that work, we feel that it is definitely an injustice to that employee.

Chairman ANDERSON. Do you not think, Mr. Brownlow, that you might sometime give us an example of what you call the fact that this work has been farmed out to "nonunion, unorganized, low-wage establishments"?

Mr. BROWNLOW. I will in a moment.

A recent example of the extent to which this vicious practice has gone is shown by the action of AEC last summer when it ordered the General Electric Co., the prime contractor at Hanford, to discontinue the performance of janitorial services in the 700 to 1,100 areas so that it might contract out the performance of such services.

The 700 to 1,000 areas at the Hanford operation are areas outside of the barricades which include administration buildings, warehouse, transportation center, supply and purchasing office, and maintenance repair shop.

These buildings historically have been occupied by General Electric personnel concerned with the operation of the Hanford Atomic Works and are presently so occupied.

They always have been serviced by janitorial employees who are a part of the General Electric production and maintenance force, covered within our NLRB certification and by our Hanford atomic metal trades council contract with General Electric Co.

The employees were told by General Electric that the AEC advised it was established Government policy to contract out this type of service when feasible, and that it was possible direct savings might be realized by such action.

The workers were notified that "if the bids are favorable, the target date for the Commission's contract would be July 1."

It is easy to understand the consternation, worry, and confusion which such announcements of contracting out set off in the minds not only of the workers in the classification directly concerned at Hanford, but throughout the entire Hanford Works and all other AEC installations as well.

Many workers in these AEC plants have been employed constantly since the early days of our atomic program when the installations were highly classified and the dangers inherent in working therein were unkown.

May I interpolate right there, Mr. Chairman, that in this instance the contractor was a large janitorial service contractor from the Pacific coast with offices or headquarters in Seattle, Wash., who I understand operates a "union" in Seattle. At least he had contractual relations with some union over there.

They laid off, or transferred, whichever would be proper to say, some 47 women or men that had been employed by General Electric Co., many from the time that the plant was initially built, and this new contractor coming in offered them work at the minimum rate established by the Federal Government, which I think was a dollar an hour, and their rate that had been negotiated was something like $1.80 per hour with all of the other fringes that go with a negotiated contract.

None of the employees saw fit to accept that proposal. As a matter of fact, it was so patently unfair even to General Electric that they offered some of these employees employment in some other operation within their plant so that they could preserve their seniority and the fringe benefits and so forth that they had accumulated.

That is only one of many, many instances, and only one of those instances that have been proposed.

Then at Oak Ridge, for example, our council obtained the first certification in 1946.

We have many persons who have more than 15 years' seniority on their jobs and have substantial interests in the rates and conditions which they have helped to establish and in the pension or retirement plan under which they are covered.

The Atomic Energy Commission, in pursuing these practices, fails to recognize the sacrifices which these workers made in moving to these areas during the construction of the plants; living in trailer camps and under almost unbelievable conditions; but who have now, in most instances, established permanent homes there. Their children are now attending schools there. Many of them own their own homes; again, under an insistent policy on the part of AEC compelling the purchase by their employees of these homes.

That may seem like a strong statement, but the employees residing in these homes, when they were operated by the Government, owned by the Government, were given the opportunity first of purchasing these homes. It goes without saying that they were not going to open these homes up to the general public unless there was some direct connection with their employment in the area in which the plant was located. Then for the AEC to adopt these proposals about the subletting of work, in many instances will result in the forced sale of homes which the Government said these people must purchase; the dislocation of present people and their families which would make

one think of the eviction of the thousands of persons driven out of their homes and places of livelihood under the worst conditions in Europe.

Chairman ANDERSON. You have used this phrase a few times about the AEC compelling the purchase by the employees of these homes.

Mr. BROWNLOW. When I say compelling, Senator, as I understand it—I think it was within what actually happened—AEC said that the homes that were rented to their employees would have to be sold. They gave the occupant of the home who was their employee, or employed in some relative position such as a storekeeper or something in the area, the first opportunity of purchasing these homes, meaning in a sense that they didn't have much choice. You either buy or we are going to sell to someone else, which would mean, of course, if they were not going to rent any of them, the person that then was occupying them under a rent proposition was just out of a place to live.

So the natural result would be that he would buy the home if for no other reason than to protect his job.

Might I further add at this time, why this idea of contracting out is suddenly being emphasized so much. I can only refer to this order of the Bureau of the Budget, this 60–2, a copy of which I have here. I think it was signed by Mr. Stans, which would indicate that is now becoming Government policy.

Again I want to make the position of myself and my organization clear.

We stand now and always have, definitely in favor of the free competitive enterprise system. However, we think there are also certain responsibilities which go along with that. We think that this procedure which is being followed by the Government at the present time not only in AEC but also the General Services Administration and the Armed Forces is clearly a violation of their obligation to their employees.

These facts demand the consideration of AEC in advance of contracting out any of the regular work of its installations.

Protests to AEC and to its operating contractors have proved of no avail in these circumstances. There is little, if any, real concern evidenced in the equity rights of the workers adversely affected by such farming out of work.

We are told by AEC that it—

> * * * is obligated to assure that its operations are conducted as economically as possible, consistent with operating requirements;

that it—

> has an obligation to conduct its activities in a manner consistent with general Government contracting policies;

that, therefore—

> it is the duty and policy of the AEC to procure supplies and services on a fixed-price basis whenever feasible.

Sometimes we find that the farming-out threat is used as a most effective device to freeze wage rates.

Take, for example, at Oak Ridge in contract negotiations during September 1958, our bargaining committee was officially notified that, at the request of AEC, the cafeteria and kitchen operations serv-

ing both the X–10 and the Y–12 plants would no longer be operated by Union Carbide Nuclear Co. after October 14, 1958, when the collective bargaining agreement would expire. The company backed up its formal statement by discharge notices to the cafeteria and kitchen workers effective October 14.

After futile efforts to get AEC to recognize its responsibilities to those workers, many of them female and with 15 or more years' service and some approaching retirement age, the only way which could be found to save this work from being farmed out to a concessionaire was to agree to a freeze of all the cafeteria and kitchen workers' wage rates for the ensuing 2-year contract period.

This was done with the consent of the workers involved in order to save their jobs and preserve their rights as Union Carbide Nuclear Co. employees.

The question may be forming in the committee's mind what is the metal trades department of metal trades organization concerned about laundry workers or cafeteria workers. But you will recall we have not been able to carve units out so we could not distinguish between one group of employees or another.

If we were going to represent any group of employees we had to be certified to represent them all.

What a sorry day—when an agency of our U.S. Government and its operating contractor use the farming-out device to chisel a group of workers out of their rights to any wage adjustments which might be obtained for 2 years.

Our cause for alarm is increased by recent developments. The Bureau of the Budget, Executive Office of the President, last September issued an instruction to all Government agencies, known as Budget Bulletin 60–2.

This bulletin, emphasizing the administration's desire to have all possible work contracted out to private industry, has served to accelerate the contracting-out problem which we face in trying to protect and preserve the job security and working conditions of the production and maintenance workers manning the basic AEC installations.

Seizing upon the policy expressed in Budget Bulletin 60–2, we know that the Chamber of Commerce of the United States, the National Association of Manufacturers and the Manufacturing Chemists' Association, for example, have all made specific and detailed requests of the AEC for release of additional work from its installations which these groups claim should be contracted out and performed by private industry, even to the ridiculous extent of insisting that contractors subcontract this work to others.

The AEC released to the press on February 12 the comprehensive response which it sent to these three groups under date of February 10 and in which it responded to the specific examples which these groups had set forth of the activities being carried on at the Government-owned plants and which they believed should be contracted out to private industrial establishments.

From the published response of AEC, we can gage the nature of the requests made by these association groups.

They would have the AEC purchase from private industry a wide variety of materials which it presently is producing and using at its installations. The extent to which these employer groups have

gone in their demands for this work make it clear that if they should even fractionally succeed, it would be a calamity of major proportions to the workers in our bargaining units at the atomic installations whose customary and regular duties have included the performance of these tasks and the production of these internally required products used by AEC.

I will not dwell in detail on the nature of the requests of these employer groups or the responses of AEC to each such request in its published reply. Suffice it to say that in no instance could we find in the response of the Atomic Energy Commisison any indication of an expression of the Commission's responsibility to the workers employed at its installations and whose efforts have contributed so materially to bringing our atomic energy program to the point of advancement which it has reached today.

It is inconceivable to us to understand how the Government can hope to maintain the high level of morale and employee cooperation at its prime installations if it continues with its contracting-out practices.

In so doing the U.S. Government through its Atomic Energy Commission is showing a dangerous disregard for the certified bargaining units which the workers in these installations have obtained through U.S. Government NLRB elections and under which they have, through their chosen representatives, negotiated their working agreements.

Certainly the small financial savings which theoretically might accrue to AEC by farming out certain integral segments of its prime installation work are more than offset by the substantial losses which will be experienced through the impact of such shortsighted policies on the morale of the basic work forces at these installations and the losses in skilled workers which are bound to occur as it becomes more apparent that the AEC has no proper regard for the job security and the preservation of employment conditions established through collective bargaining at its projects.

It is the firm position of the metal trades department that the Government of the United States, through its Atomic Energy Commission, should not directly or indirectly authorize or allow the contracting or subcontracting of work which normally has been performed by its operating contractors at its Government-owned installations to subcontractors or other contractors unless such contractors specifically assure the Government:

First, that they will retain the same employees as have been performing such work;

Second, that they will maintain the same conditions, benefits, and privileges in all respects that such employees have been enjoying; and,

Third, that they will agree to not less than the collective bargaining relationships with the employees' chosen labor organization in the same manner as though they were a successor contractor or successor employer and will assume all the obligations of such successorship.

Even if all such assurances could be guaranteed, it would still be essential that such employees be protected against the possibility of such subcontractor canceling out and thus slipping away from the responsibilities to these workers.

Therefore, it would be necessary that, in addition, some suitable guarantee should be made by both the Atomic Energy Commission and the prime contractor that, should the subcontractor cancel out after he has been granted such work, adequate safeguards exist to assure the protection of all of the rights of the workers involved.

We would urge that the Joint Committee on Atomic Energy direct its attention promptly to this phase of AEC functioning and the unfavorable effects of the same on the workers manning these installations and who are vital to the forward march of our atomic energy program.

If the Joint Committee does not succeed in obtaining firm assurances from the Atomic Energy Commission on this important phase of its functioning, then we believe that appropriate legislation should be introduced.

The metal trades department will be happy to cooperate in all possible ways with the committee in this regard and we indeed appreciate your kindness in giving us this opportunity to bring this practice to your attention.

Thank you.

Chairman ANDERSON. Mr. Brownlow, have you had any correspondence with the Atomic Energy Commission about this?

Mr. BROWNLOW. Yes.

Chairman ANDERSON. Would you mind at some later date supplying us with some of that correspondence so we can know where to start on it?

Mr. BROWNLOW. I would be most happy to.

As a matter of fact, I am sure that Senator Jackson and Senator Magnuson from the State of Washington have also had considerable correspondence with the Commission over the Hanford incident.

Chairman ANDERSON. I know that.

I was going to suggest to you that you give us some copies of it in the committee.

From reading your paper, it might sound as if this applied only to janitorial workers, cafeteria workers, and people employed in the laundry. Do you not think this goes far beyond that?

Mr. BROWNLOW. It does by all means.

Chairman ANDERSON. For instance, we had a discussion the other day about some things that happened in one laboratory that might be transferred to a private industry, under the chamber of commerce recommendation and the manufacturers association recommendation. Would that not have some influence on some of these people who had rights?

Mr. BROWNLOW. That is right, it would have.

As a matter of fact, this may sound like an exaggeration but if they went as far as the recommendations of the U.S. Chamber of Commerce, many of your atomic installations as presently constituted would merely be "farming out agencies" and none of the work would be performed and that is that. These people would be deprived of their jobs.

Chairman ANDERSON. I have felt that same way about it.

Are there questions.

Representative DURHAM. Mr. Brownlow, I notice you give a rather long history of the operations. I suppose the union operates in all of these installations that you mentioned.

Mr. BROWNLOW. Yes.

Represenative DURHAM. Could you give us an estimate of the number of people that would be involved under the complaint?

Mr. BROWNLOW. As nearly, Mr. Durham, as I can recall, at the last report to the metal trades department convention which I made, I said that there were some 60,000 employees eligible or at least those that were considered eligible for organization under both NLRB and AEC standards, of which we represent some 40,000.

Representative DURHAM. At the present time you actively represent 40,000; is that correct?

Mr. BROWNLOW. That is right.

Representative DURHAM. You just point out on here where you had the trouble, and it does not give a very clear picture as to how much the overall impact is on the whole organization.

Mr. BROWNLOW. I have a large list of figures here, Mr. Durham.

Representative DURHAM. You can supply them for the record. It is not necessary to go into detail.

Mr. BROWNLOW. I would be most happy to send them over.

Representative DURHAM. I think it would be helpful to the committee in trying to assess the real problem involved.

Mr. BROWNLOW. There is a real problem involved, sir.

Chairman ANDERSON. Will you do that, Mr. Brownlow, and furnish to the committee for its files such material as you have there?

Mr. BROWNLOW. Yes, sir.

Chairman ANDERSON. Of course, the number of people who would be disturbed would depend to a degree on how rapidly the Commission put into effect this farming-out policy.

Mr. BROWNLOW. Yes.

(The material refered to above is on file with the Joint Committee.)

Chairman ANDERSON. Mr. Bates.

Representative BATES. I would like to ask Mr. Brownlow, Does the AFL–CIO as a whole support the policy you enunciated here?

Mr. BROWNLOW. We discussed the matter before the last meeting of the executive council of the metal trades department. Sitting on the council were several members of the building and construction trades department executive council, and they are in complete concurrence.

I have never taken the matter up with the convention of the AFL–CIO as such.

Representative BATES. The reason I ask that question is this: We have had a lot of experience in Congress with this particular problem. Certainly we have in Boston.

Mr. BROWNLOW. I know that.

Representative BATES. Or the paint shop in Norfolk or the various laundries operated by the post exchanges. You get into the situation where the people who have the jobs want to continue the jobs. Outside you have union employees working for paint companies, working for Plymouth Cordage Co. in Plymouth, Mass. They are union members. They take the opposite position from what you have indicated, because they want to retain the jobs which they have had, the

seniority which they have built up, and they believe what you advocate is a Government subsidy.

That is the reason I asked the question. You have different union people taking different positions.

Mr. BROWNLOW. There is some difference, Mr. Bates.

General Services Administration, for instance, is compelled to let to the lowest bidder. Consequently, if they take a function out of the Navy, Ordnance, or AEC and put it up for public bid and a low bidder who is considered a responsible bidder, regardless of his labor relations policy, they are compelled to give him that contract.

Candidly, many of our unions are adopting a rather shortsighted policy in that respect. I would be the last to, as I said before, to advocate to the Government any policy which would make it a strictly Government operation. These people have been certified for this work and certified by a Government agency. They have moved their families into these areas.

One example, for instance, the suggestion was made that they were going to contract out the machine shop work from the Hanford plant. I do not know how far that got. It was to be to some firm in Chicago.

We have no assurance that the firm in Chicago that would succeed in obtaining that contract would even meet the same conditions as the Hanford employees, but at the same time, if they put two or three hundred machinists out of work at Hanford, what are those machinists going to do?

Representative BATES. I want to point out that in the experience I have had with this particular problem, the reaction of the union members depends upon where they stood in a particular situation.

If there was an opportunity for them to get jobs which were being performed by a Government agency, then they are all for it, if it benefited them.

Mr. BROWNLOW. That is right, if it benefited them.

Representative BATES. But the converse is true if the situation was the opposite.

I just wondered how the AFL was going to reconcile this problem.

Mr. BROWNLOW. We won't have too much trouble with it because bear in mind, Mr. Bates, these are contractors themselves. It is a little different than the defense operations.

Representative BATES. There is a great deal of parallel there, too.

It is the same problem you run into on imports. The AFL–CIO believe in a liberal free trade policy. But you get people in my neck of the woods who are going to lose their job, they do not go along with that.

Mr. BROWNLOW. Let me say they don't believe in that free trade policy so much today as when there was not much coming in.

Representative BATES. I wanted to find out if the AFL–CIO was in complete agreement with what you indicated, and you indicate they are at headquarters.

Mr. BROWNLOW. That is right.

Chairman ANDERSON. Are there other questions?

If not, thank you very much, Mr. Brownlow.

Chairman ANDERSON. The next witness is Mr. Oliver Townsend, Office of Atomic Development, New York State.

STATEMENT OF OLIVER TOWNSEND, DIRECTOR OF ATOMIC DEVELOPMENT, STATE OF NEW YORK

Chairman ANDERSON. We are very glad to welcome you back here, Mr. Townsend.

Mr. TOWNSEND. Thank you very much, Mr. Chairman.

My name is Oliver Townsend; I am the director of the Office of Atomic Development of the State of New York.

The purpose of this statement is to report to you the actions taken by New York State as a result of the passage in the last session of Congress, upon the unanimous recommendation of this committee, of the Federal-State cooperation amendment mainly constituting new section 274 of the Atomic Energy Act of 1954, as amended.

You may recall that I testified in favor of this amendment before this committee last year, and that I stated at that time that New York State would undertake to negotiate an agreement with the Atomic Energy Commission under the amendment if it became law.

The amendment was signed by the President on September 24, 1959. On September 28, I informed the general manager of the Atomic Energy Commission by letter that the State of New York wished to proceed with the negotiation of an agreement with the Commission under which the State, as provided by the new amendment, would assume exclusive jurisdiction within the State over the possession and use of byproduct materials, source materials, and special nuclear materials in quantities not sufficient to form a critical mass.

This letter proposed, as a first step, that the State and the Commission enter into a preliminary agreement under which selected personnel from the State would be assigned for indoctrination purposes to the Commission's Division of Licensing and Regulation in Washington, D.C., and to the Inspection Division of the Commission's New York Operations Office.

We proposed that this be accomplished under an arrangement whereby the State would pay the salaries of the personnel involved and the Commission would pay their travel and subsistence expenses.

This financial arrangement was proposed by us pursuant to section 274.i of the amendment, which states in part that:

> * * * any * * * assistance by the Commission shall take into account the additional expenses that may be incurred by a State as a consequence of the State's entering into an agreement with the Commission * * *.

Language such as this was initially proposed by New York State to this committee and we deeply appreciate the weight which the committee has attached to this suggestion as evidenced by its inclusion in the law.

The Commission responded to our expression of interest by means of a letter dated October 12, 1959, from the acting director of the Division of Licensing and Regulation. This letter acknowledged our interest and stated that plans for implementing the new Federal-State cooperation amendment were being prepared and that the Commission would be in touch with us as soon as these plans had been completed.

Meanwhile we in New York decided to proceed to prepare ourselves to enter into an agreement with the Commission at the earliest

practicable date, and with this end in view the State office of atomic development submitted certain specific recommendations for action to Governor Rockefeller on December 1, 1959. These recommendations were submitted to the Governor with the unanimous concurrence of both the State's atomic energy coordinating council, consisting of the heads of the principal agencies in the State concerned with atomic energy, and the State's general advisory committee on atomic energy, consisting of 15 of the State's foremost experts in the atomic field from industry, labor, science, education, and the law.

The Governor approved these recommendations and in turn has proposed appropriate implementing legislation to the New York Legislature, which is now in session. The Governor's proposals were three in number and were briefly as follows:

First, that the Governor be expressly authorized by law to enter into the agreement with the Commission envisioned by section 274.b of the new Federal-State cooperation amendment;

Second, that the office of atomic development be expressly authorized to enter into any preliminary agreement on behalf of the State that might be considered desirable under section 274.i of the amendment;

And third, that the State department of health be expressly authorized to license the possession and use of any materials within its jurisdiction covered by an agreement between the State and the Atomic Energy Commission.

With regard to this last-named proposal, it should be borne in mind that there are in New York State three regulatory agencies primarily involved in the control of radiation within the State. These are the State department of labor, with jurisdiction in industrial facilities all over the State; the State department of health, with jurisdiction outside of industrial facilities in all parts of the State with the exception of the city of New York, and the New York City Department of Health, with jurisdiction within the city but not including industrial facilities.

Two of these agencies, the State department of labor and the New York City Department of Health, appear clearly already to possess licensing authority within their jurisdictions. There appears to be some ambiguity, however, under present law, as to the authority of the State department of health to regulate by means of a licensing system.

We therefore have proposed legislation designed to remove this ambiguity and to put the State health department on a par with the State department of labor and the New York City Department of Health in the interest of removing any possible roadblock to our efforts to enter into an agreement at the earliest practicable date with the Atomic Energy Commission.

The role of the State office of atomic development in these matters is to coordinate the activities of the three regulatory agencies within the State and to correlate these activities with those of the Federal Government with the objective of achieving uniformity with respect to codes, standards, and administrative procedures.

Bearing in mind that the New York State Legislature will remain in session only until the end of March, we on February 5, 1960, dispatched a letter to the general manager of the Commission describing

the preparatory steps we are taking in New York and requesting an opinion from the Commission as to their adequacy.

In response to this letter, I met informally with representatives of the Commission's Office of Health and Safety and Office of the General Counsel on February 10, and, as a result of this meeting, feel confident that New York State will be legally prepared to enter into an agreement with the Commission as soon as one can be negotiated.

We are now, along with other States, awaiting publication of the Commission's criteria establishing eligibility for an agreement, and, assuming that these criteria are acceptable to us, plan to proceed into the negotiation phase with vigor and purpose.

We in New York are interested in entering into one of these newly authorized agreements with the Atomic Energy Commission for several reasons:

First,we believe that increased regulatory activity and authority by the States serves the purpose of normalizing the atomic industry and making it more like other industries so that it is not always both literally and figuratively a Federal case. This in turn we believe serves to imbed atomic energy more deeply into the governmental and industrial roots of the United States and thereby helps to encourage and perpetuate progress to the benefit both of the States involved and the cause of atomic energy generally.

Second, we believe that increased activity and responsibility on the part of States serves to educate States about atomic energy and bring additional competent judgments to bear on the important problems of health and safety in the overall public interest.

Third, we are inclined to doubt that as atomic energy becomes increasingly ubiquitous the Federal Government can continue to stretch itself widely enough to keep all aspects of atomic energy under adequate control. As time passes it seems to us that the Federal Government must constantly and gradually contract its area of responsibility to the more esoteric and pioneering aspects of atomic activity or run the risk of a deterioration in the effectiveness of health and safety controls.

And, fourth, we in New York want to help the development of an atomic industry within the State, and we think that this is easier to accomplish if the State has the stature and authority that goes with some measure of control.

With regard to this matter of development, our office has arrived at certain objectives with the concurrence and assistance of our advisory committee and coordinating council. These are primarily as follows:

One, that there exists within the State a definite plan for the construction of an atomic powerplant in addition to the plant now being built by the Consolidated Edison Co. at Indian Point.

Two, that there be constructed within the State a plant for the reprocessing of irradiated nuclear fuels and the recovery therefrom of valuable unused fuel and by products.

Three, that there be established within the State a site for the storage and disposal of radioactive byproducts and wastes.

Four, that there be constructed within the State a high flux, high-powered materials test reactor to serve the Knolls Atomic Power Laboratory as well as other Government installations and fuel element fabricators in the northeast.

Five, that there be located within the State at least one port facility for the transshipment of irradiated fuel elements and the servicing of nuclear-powered vessels.

And six, that the State undertake an industrial education program to increase the utilization of radioisotopes by the State's industry.

We also plan in New York State to establish and maintain a directory of radiation experts and a catalog of radiation equipment which will be placed in the hands of all local police and fire officials for use by them in the event of an accident believed to involve radioactive materials.

With respect to a possible agreement under the new Federal-State cooperation amendment, we are now awaiting action by the New York State Legislature on the Governor's implementing proposals and publication of the Atomic Energy Commission's criteria.

Our hope and expectation is that at the atomic energy hearings held by this committee a year from now we will be able to report the existence of such an agreement between the State of New York and the Commission.

Chairman ANDERSON. Thank you, Mr. Townsend.

Let me turn now to page 5 of your statement:

"First, we believe that increased regulatory activity and authority by the States serves a purpose," and so forth.

At the present time, most of the regulatory activities are in the hands of the Federal Government.

Mr. TOWNSEND. That is right.

Chairman ANDERSON. For example, we are having some discussion about the site of a reactor. Do you believe that the power to decide on sites should pass eventually to the States?

Mr. TOWNSEND. I think that there should be probably an interim period where both the State and the Federal Government has a voice in regard to site and after the passage of some time, while this plan were in effect, then it could be considered whether or not maybe States are not ready to take that on.

Last year we suggested in the hearings that Mr. Holifield had on the Federal-State cooperation amendment that there be included within it language which would give the State the authority to approve the site of a proposed facility before the application for license to the Atomic Energy Commission was considered by the Commission. That was not included in the law.

Chairman ANDERSON. I know, because you have some problems. You take the Northern States powerplant, their building is just across the line in South Dakota, but the people who worry about it are the people from Minnesota.

Do you think that the people of South Dakota, which is the mere location of the plant, should have the final word or the people in Minnesota who might be exposed by some radioactive incident?

Mr. TOWNSEND. I think as time passes it will be possible to negotiate and arrive at interstate compacts on matters of this sort.

Chairman ANDERSON. When you get to an interstate compact, that has to come back to the Congress for approval so you get the Federal Government back into it again?

Mr. TOWNSEND. In regard to the approval of the compact, yes.

Chairman ANDERSON. At the top of page 6 you say that—

it seems to us that the Federal Government must constantly and gradually contract its area of responsibility.

You think eventually that this is an operation that will pass more to the hands of the States.

Do you believe that there is a difference in the size and capacity of the States?

Mr. TOWNSEND. Yes.

Chairman ANDERSON. For instance, the State of Nevada has quite a bit of activity, but it may have very little money to police this work, whereas the State of New York might have quite a little.

Mr. TOWNSEND. The procedure followed by the amendment passed last year, I think accommodates that very well. It provides for negotiated agreements with individual States.

For example, if about a half-dozen States under the new amendment were to negotiate agreements with the Atomic Energy Commission, it would take probably 50 percent of their radioisotope regulatory load off their shoulders.

In States where they obviously are not prepared to do this, the Federal Government hangs on to that authority until they are prepared.

Chairman ANDERSON. Farther down on page 6, you start off with some objectives and you say—

one, that there exists within the State a definite plan for the construction of an atomic powerplant in addition to the plant now being built by the Consolidated Edison Co. at Indian Point.

There was a news article in the New York Times that indicated that Mr. Moses of the New York State Power Authority would like to participate in atomic power development and construct and operate atomic powerplants. Were you familiar with that?

Mr. TOWNSEND. I am familar with that.

It seems to me in New York there are three possibilities for one or more additional atomic powerplants, and probably the most immediate is the city of Jamestown, which has an application before the Atomic Energy Commission now for a so-called second round plant of 16,500 kilowatts capacity.

The site that has been selected for that plant, if Jamestown is approved by the Atomic Energy Commission, exists on land that is set aside for a park and legislation was required in order to make it available for power purposes.

Just before I came here I received word from Albany that that legislation has passed the State legislature and therefore, if Jamestown is selected, that site is now available or will be available to the Commission for the second round plant. That is one possibility for a plant in New York.

Another possibility is that one or more private utilities will pick this up—this kind of thing.

There has recently been organized within New York State a seven-utility group to study new technologies, including particularly atomic energy, and this group seems to be rather well organized to take on a powerplant project if it decided to do so. So I would think this is a possibility.

The third possibility is the New York State Power Authority, which has suggested that it have its legislation revised to permit it to build an atomic powerplant if it decided to do so. It presently functions under a law which limits its activity to hydrodevelopment.

Chairman ANDERSON. Was not that request turned down by the Rockefeller administration?

Mr. TOWNSEND. This request has not been acted on.

Our office made no recommendation on that in our report to the Governor. Our theory was that there are a number of questions that have to be answered before you address yourself to the problem of atomic power there.

The first question is, do you need backup power for the hydro? This would be the rationale for a thermal plant.

It was our feeling that discussion of this question could be carried on at some length without ever mentioning the phrase atomic energy.

Then the next question was, if backup power is required, should it be generated by the power authority or should they purchase it?

This again is a question that can be discussed at some length before you mention atomic energy. It is only if those two questions are answered in the affirmative that the question of whether or not it is atomic or coal or oil or something else is raised, and it is at that point that our office, together with our advisory committee and our coordinating council appropriately should enter the picture, we think.

Chairman ANDERSON. I notice in the Times for last January 3 an article that starts off:

A task force named by Governor Rockefeller last June to study the State's power needs and resources has recommended joint development of nuclear power by private utility systems. Headed by Vice President John E. Burton, of Cornell University, former chairman of the State authority, the seven-man committee filed its report with the Governor today.

It urged that private utilities conduct research, and so forth?

Has there been a new private syndicate established?

Mr. TOWNSEND. There is a new seven-utility group established in New York State and chairman of the group is Mr. Beebe, who is now retired and was chairman of the Rochester Gas & Electric Co. This group has announced that it plans to do feasibility studies on atomic power. It has not announced any intention to build the plant.

Chairman ANDERSON. Do you know the members of the syndicate?

Mr. TOWNSEND. They are the seven utilities of New York State. I could provide the names if you like.

(A letter dated March 1, 1960, from Mr. Townsend, together with the advisory committee recommendations, and a memorandum from Governor Rockefeller to the State legislature, follow:)

STATE OF NEW YORK.
EXECUTIVE DEPARTMENT.
OFFICE OF ATOMIC DEVELOPMENT.
Albany, N.Y., March 1, 1960.

Hon. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy, Congress of the United States, Washington, D.C.

DEAR SENATOR ANDERSON: During my testimony before the Joint Committee on February 24 I stated that I would provide to you the names of the companies which are members of the new seven-company New York State utility group, called the Empire State Utilities Power Resources Associates, which has been organized to complete a State power pool grid system and to develop an atomic

power program. These companies, together with the names of the individuals representing them on the group's executive committee, are as follows:

Consolidated Edison Co. of New York: Charles Eble, president.
Niagara Mohawk Power Corp.: Earle J. Machold, president.
Long Island Lighting Co.: E. W. Doebler, chairman of the board.
New York State Electric & Gas Corp.: Joseph M. Bell, Jr., president.
Rochester Gas & Electric Corp.: Robert E. Ginna, chairman of the Board.
Central Hudson Gas & Electric Corp.: Ernest R. Acker, president and general manager.
Orange & Rockland Utilities, Inc.: Charles L. Hulfswit, president.

The executive director of the group is Mr. Alexander M. Beebee, former president and chairman of the board of Rochester Gas & Electric Corp.; the chairman of the power grid program is Howard Harrington of the Niagara Mohawk Power Corp., and the chairman of the atomic power study is John R. Dunning, dean of engineering of Columbia University.

Because of later references in the hearings to New York State's atomic developmental program, which were made by others following my testimony, I would also like to take this opportunity to transmit to you for inclusion in the record a copy of the eight specific recommendations the State office of atomic development made to Governor Rockefeller last December, together with a copy of the Governor's memorandum to the legislature proposing implementing actions with respect to certain of the recommendations.

I deeply appreciate the cordial manner in which I was received by the committee on February 24 and we shall be pleased to provide you with any further information concerning our activities that you may desire.

Sincerely yours,

OLIVER TOWNSEND, *Director.*

SPECIFIC RECOMMENDATIONS

1. That the State government contribute to the costs of research and development leading directly and specifically toward the construction within the State of (*a*) preferably a full-scale atomic powerplant which will give reasonable promise of being economically competitive, except for research and development costs, on an averaged annual basis over its useful life with conventionally fueled powerplants in the same geographical area, or (*b*) a prototype atomic powerplant which would lead directly toward the construction of an economically competitive full-scale atomic powerplant of the same type. The powerplant, whether full-scale or prototype, would be of a type selected by its sponsoring utility or utilities. It would be either part of an anticipated new national program, or deemed by the State and sponsoring utility or utilities to be more suitable for New York State than any project in the national program, or deemed by the State and sponsoring utilities to be suitable for New York State i nthe absence of a national program. The cost contributed by the State would be at least matched by the sponsoring utility or utilities, some of which might be located outside of the State, and not paid until completion of the plant. When completed, the plant would be available to the higher educational institutions in the State to the maximum extent possible for training purposes, and all information produced by research and development work carried on with State funds would be readily available to the people, including the industries and educational institutions, in the State.

2. That the State government locate within the State one or more sites at which radioactive byproducts and wastes produced by industrial, medical, agricultural, and scientific organizations could be concentrated and stored in a manner consistent with the public health and safety. It would be understood that such a site, if found, would be acquired by either the Federal or State Government and that it would be located in as close proximity as possible to a suitable site for a uranium fuel recovery and reprocessing plant.

3. That the State government locate within the State one or more sites at which a high-powered nuclear materials test reactor could be constructed and operated in a manner consistent with the public health and safety. It would be understood that, if the construction of such a project were not undertaken by private industry, the State would acquire such a site and make it available to the Federal Government provided that the cost of the site is not excessive, that the Federal Government agrees to utilize the site for the purpose intended, and that the Federal Government fails to acquire the site itself.

4. That the State government locate within the State one or more port facilities capable of handling the fueling and servicing of atomic-propelled vessels and the shipping of used uranium fuel in a manner consistent with the public health and safety.

5. That the State in the next few years enter into one or more arrangements with educational institutions under which the State would provide a total of up to $1 million of assistance not otherwise available on no more than a matching basis in the establishment of one or more nuclear facilities, designed primarily for training purposes, in an area outside of the area served for training purposes by the Western New York Nuclear Research Center in Buffalo or the Brookhaven National Laboratory at Upton, Long Island.

6. That the Governor be expressly authorized by statute to enter into an agreement or agreements on behalf of the State wth the Atomic Energy Commission whereby the Federal Government will discontinue, and the State would assume, regulatory authority with respect to atomic energy activities relating to byproduct materials, source materials, and special nuclear materials in quantities not sufficient to form a critical mass within the State now or hereafter regulated by the Federal Government.

7. That the State department of health be expressly authorized by statute to license the use of atomic energy materials covered by any agreement entered into between the Governor of the State and the Atomic Energy Commission.

8. That the office of atomic development be expressly authorized by statute to prepare, maintain currently and distribute within the State for use in the event of an accident, fire, or disaster believed to involve radioactive materials, a roster of qualified radiation experts and a list of the type and location of useful instruments and other specialized equipment within the State, and to cooperate with the Federal Government and State civil defense commission in establishing training programs relating to handling such accidents, fires or disasters.

MEMORANDUM BY THE GOVERNOR

DECEMBER 3, 1959.

To the Leaders of the Legislature:

The year 1959 has marked for New York State the beginning of a coordinated program of State action in the development and use of atomic energy for peaceful purposes. Legislation enacted at the 1959 session recognized that atomic energy is a matter of important concern to the economic growth and the health and safety of the people of the State.

New York has been the leader in the medical uses of atomic energy. It has, however, lagged with respect to the development of atomic industry. The specific steps taken in 1959 point toward placing New York in a position of genuine leadership in atomic matters. These steps include:

1. Enactment of a State atomic energy law creating the office of atomic development;

2. Initiation of the Western New York Nuclear Research Center and negotiation of a contract between the State and the University of Buffalo for the construction of the center;

3. Completion of a definitive study by the office of atomic development identifying economically sound atomic projects for location in New York;

4. Initiation of discussions between the State and the U.S. Atomic Energy Commission looking to the development of an agreement under which the State would assume regulatory authority of certain atomic energy activities;

5. Initiation of a systematic review of all rules, regulations, and ordinances pertaining to atomic energy within the State.

It is noteworthy that the act creating the office of atomic development anticipated the action taken by the Federal Government in September of this year when it authorized the transfer of regulatory control of certain atomic energy activities from the Atomic Energy Commission to qualified States. Through its forward-looking atomic energy program New York now stands prepared to assume such regulatory control.

When the State atomic energy law was enacted early in 1959, it was recognized that all the specific steps to encourage atomic development could not be taken in that initial legislation. The time is now at hand to strengthen the State's activity with respect to atomic enegy. A well-conceived program for 1960 has been developed based upon the comprehensive report of the office of atomic development. I am submitting for your consideration a copy of this

report with this memorandum. I have found the report of great value in understanding the difficult and technical problems associated with atomic development.

The report can and should be implemented by legislation at the 1960 session. Such legislation would focus on three major areas: public health and safety with respect to nuclear materials, development of atomic industry in New York and cooperation with the Federal Government in the regulation of atomic energy.

1. Public health and safety with respect to nuclear materials

Atomic industry can be and must be safe industry. As the report of the Office of Atomic Development points out the peaceful development of atomic energy can be among the safest of human endeavors. Risks associated with the peaceful development of atomic energy cannot, however, be ignored. These risks can be effectively controlled by careful planning. Such planning should take into account that the hazards of radio-activity may not be so great in themselves as in the possibility that they be misunderstood and thus not handled in the proper manner.

I am proposing legislation to direct the Office of Atomic Development to cooperate with the Federal Government, the State Civil Defense Commission and appropriate agencies of State and local government, including our fire and police organizations in establishing training programs relating to the handling of accidents, fires, or disasters believed to involve radioactive materials.

In order to be further prepared to cope promptly and effectively with any accident which might involve radioactive materials, I am also recommending legislation which would direct the Office of Atomic Development to prepare and maintain a roster of persons within the State qualified in the detection and handling of radiation hazards and a list of the type and location of technical equipment which could be of use in connection with any such accident. The roster and list would be distributed throughout the State, available to all agencies of government concerned with the public health and safety.

These two measures would provide important steps in discharging the State's continuing responsibility for the public health and safety as we move into the atomic era.

2. Development of atomic industry in New York

The creation of jobs through economic expansion requires forward looking policies to seize opportunities springing from nuclear developments. New York, as a highly industrialized, highly populated State, can, through careful planning, benefit to the maximum extent for the exploitation of atomic energy.

Such planning is being carried forward by the Office of Atomic Development, which in its immediate recommendations recognizes that the proper role of the State is to act as a catalytic agent to provide incentives for atomic development within the State.

To implement these recommendations, I am submitting proposed legislation which would direct the Office of Atomic Development to locate within the State, with due regard for the public health and safety:

(*a*) sites at which radioactive byproducts could be concentrated and stored;

(*b*) sites at which an atomic test reactor could be constructed and operated; and

(*c*) port facilities capable of handling the fueling and servicing of atomic propelled vessels and the shipping of used uranium fuel.

(*a*) *Storage sites for radioactive byproducts.*—The use of atomic fuels results in the creation of radioactive waste materials which must be safely disposed of. Atomic industry will be attracted to those areas which provide safe and convenient sites for the disposal of such waste materials. The early identification of such sites is necessary, not only as a health and safety measure, but because their existence would serve to encourage the growth of atomic industry within the State. It is contemplated that such sites, when located, would be acquired either by the State or Federal Government.

(*b*) *Sites for an atomic test reactor.*—Nuclear test reactors are high-powered reactors which do not generate electricity or propel ships, but which are used to develop and test the fuel elements that will be used in future power and propulsion reactors. Such test reactors are vital to the development of the fuel elements that will feed the atomic powerplants and ship propulsion units of the future. No nuclear test reactor exists in the Northeast, despite the fact that most of the potential users of such a reactor are located in this area of the coun-

try. The existence of such a reactor should substantially stimulate atomic industrial development within the State. The identification of a suitable site in New York for such a reactor is, however, a prerequisite to its construction by private industry or the Federal Government.

(*c*) *Port facilities for the atomic era.*—In order to preserve New York's preeminence in the maritime commerce, it is vital to plan for the atomic fleets of the future. Now is the time to determine the feasibility of locating within the State safe port facilities capable of handling the fueling and servicing of nuclear ships as well as the shipment of used uranium fuel entering or leaving the State by sea.

These three measures would constitute significant steps toward improving the climate for atomic development within the State. I recommend them for your favorable action.

3. Cooperation with the Federal Government with respect to regulation of atomic energy

The Federal Government recognizes the soundness of State control over some of the peaceful uses of atomic energy. In September 1959, the Congress established procedures for the discontinuance of the Atomic Energy Commission's regulatory authority with respect to radioisotopes, natural uranium and thorium, and small quantities of fissionable materials and for the assumption of this authority by the States. The Atomic Energy Commission was authorized to enter into agreements with any State for the transfer of such regulatory authority from the Commission to the State, and to provide for the performance of inspections or other functions on a cooperative basis.

The State should assure that the dynamic forces of private industry are put to work to bring the benefits of the atomic age to its people. Hand in hand with this new role of the State in atomic matters must go the development of State regulations designed to protect fully the health and safety of the individual citizen.

In order to provide for such State regulation, I recommend legislation:

(*a*) authorizing the Governor, on behalf of the State, to enter into an agreement or agreements with the Federal Government whereby the State would assume regulatory authority over atomic byproduct materials, source materials and special nuclear materials in quantities not sufficient to form a critical mass;

(*b*) authorizing the office of atomic development, with the approval of the Governor, to enter into agreements with the Federal Government under which the State will perform on a cooperative basis with the Federal Government inspections or other functions with respect to atomic energy activities within the State, and

(*c*) authorizing the State department of health to license the use of atomic energy materials.

Such express authority will permit the State to assume appropriate regulatory control over matters relating to atomic energy and effectively to protect the health and safety of the people.

The legislative proposals which I have outlined, do not embody two of the recommendations made by the office of atomic development in its report. These matters are under continuing consideration. One relates to the development of an additional atomic power plant within the State. The other relates to the establishment of additional nuclear facilities for training purposes at educational institutions. The question of atomic power generation should appropriately await the imminent report of the Governor's committee on power resources. The establishment of additional nuclear facilities at educational institutions should be considered in the light of the work presently going forward for the Western New York Nuclear Research Center.

Conclusion

The measures which I have outlined are embodied in two proposed bills which I am submitting to you with this memorandum with the request that they be prefiled. The enactment of this legislation would advance the position of New York toward leadership in the field of atomic energy by furthering the public health and safety with respect to nuclear materials, by stimulating atomic industry within the State, and by authorizing the State to assume regulatory control over various aspects of atomic development that touch upon the well-being of the citizens of the State.

(Signed) NELSON A. ROCKEFELLER.

Chairman ANDERSON. What did your advisory committee recommend as to the participation of the New York Power Authority in the atomic power development?

Mr. TOWNSEND. Our committee said that we thought that the public policy question of whether or not the authority should generate power from any source other than hydro should be answered before we addressed ourselves to the problem of whether it should be coal or atomic.

One member of the committee, General Farrell, a consultant to the New York State Power Authority, submitted a separate opinion on that, recommending that the committee and our office recommend to the Governor that the power authority have permissive legislation, permitting it to build an atomic powerplant if it later on decides to do that.

We did not make that recommendation.

Chairman ANDERSON. He said it is recommended that the report on atomic power include a recommendation for permissive State legislation authorizing the power authority to build and operate nuclear powerplants.

Mr. TOWNSEND. That is what he suggested.

Chairman ANDERSON. Was he the only member of the committee that so recommended?

Mr. TOWNSEND. That is right.

Chairman ANDERSON. I hope you continue to keep the committee informed as to the operations there. I think it is an extremely important venture that you folks are in.

You recommend here that there be established within the State a site for the storage and disposal of radioactive byproducts and waste. Are you ready to receive it from all the other 49 States?

The problem is to decide what to do with this.

Mr. TOWNSEND. There are two requirements, I think, for waste disposal sites now in this country. One is the so-called low-level requirement. This is the regional program of the Atomic Energy Commission. If the Commission decided to place one of these regional sites in New York State, we would accept from the region low-level wastes. We would hope that as time passes additional sites would be established in the northeastern region and gradually the area served by the New York site would contract.

The other requirement for a waste disposal site is for high-level wastes and this goes very closely with the establishment of a fuel reprocessing plant.

There is a group of utilities—five utilities—looking into now the feasibility of designing and building a privately owned and operated fuel reprocessing plant. We would like very much for those people, if they decide to build that plant, to consider New York as a possible location. We think if they do, we have to be in a position to take the radioactive residues off their hands. This we have in mind also in connection with waste disposal.

Chairman ANDERSON. Are there any questions?

Representative HOSMER. Yes, Mr. Chairman.

You make reference to the State of New York having jurisdiction over most of the State through its department of labor and department of health. But in New York City, your city authorities have jurisdiction in connection with radiation; is that right?

Mr. TOWNSEND. Outside of industrial facilities.

The labor department has jurisdiction within industrial plants.

Representative HOSMER. What bothers me is that in this enabling legislation that was passed last year, it had in mind the States as such and not their subdivisions.

Do you see any problem at all in that respect, assuming you sign a contract?

Do you think that your contract with the Commission can include authority to delegate some responsibility to the city of New York, for instance, or are you going to have to go in the city's boundaries and exercise whatever authority you acquire through the contract directly?

What is your thinking on that problem?

Mr. TOWNSEND. It is our opinion that the agreement between the Governor of the State and the Atomic Energy Commission will take care of this. It provides for transfer from the Atomic Energy Commission to the already established regulatory agencies within the State, each with separate jurisdictions and each would take this on within their jurisdictions.

Representative HOSMER. In short, the contract will control, and if it is not included in the contract expressly it is not implied and does not flow to a subdivision of a State?

Mr. TOWNSEND. In the first place, we don't want to make a move here unless we have the city of New York and the State department of labor and the State department of health with us. We will try to carry forward as far as we can committing these regulatory agencies to an agreement.

This is a legal question. We are aware of it.

Representative HOSMER. You are satisfied that legally the law we passed last year permits a contract to be written which does in fact pass it not only to the State but to subdivisions within the State; namely, cities, counties, districts, whatever else you might happen to have?

Mr. TOWNSEND. It is my understanding there is no legal road block such as that to an agreement between the New York State and the Atomic Energy Commission. We have thought of this and we have looked into this and this is the legal opinion we have received.

Representative HOSMER. Thank you.

Chairman ANDERSON. Mr. Ramey has a question, Mr. Townsend.

Mr. RAMEY. On page 54 of your report to the Governor of last December, you recommend that the State government contribute to the costs of research and development leading directly or specifically toward the construction of either a full scale plant or prototype plant and mentioning something about the State matching the research and development cost of the utility.

Has the Governor or the administration given any view on this proposal?

Mr. TOWNSEND. That recommendation has not been acted on.

Mr. RAMEY. As you know, the Commission, on large-scale plants, in certain areas they think they are almost economic and they are looking toward possibly helping out a couple of plants on research and development assistance.

Would you contemplate that perhaps you might have three-way agreement with the State contributing some money, the utility contributing some money, and the AEC throwing in the rest on a larger scale plant?

Mr. TOWNSEND. We had that in mind when we made that recommendation, depending upon the views of the people who actually built the plant. If they wanted an arrangement such as that and proposed an arrangement such as that to us, we thought it would be a good arrangement.

Mr. RAMEY. Are there areas in New York State, apart from the St. Lawrence development, that are high-cost conventional fuel areas that might be a place where it might be getting pretty close?

Mr. TOWNSEND. It is medium to high cost.

Chairman ANDERSON. Are there other questions?

Representative HOLIFIELD. Yes, Mr. Chairman.

Mr. Townsend, I have been watching the work of the New York State government in the field of atomic energy and in my opinion, it is the most alert State in the Union in regard to these problems. I know a great deal of credit belongs to the work that you have done in this field.

I certainly want to compliment New York State in recognizing these problems and taking steps to assume State responsibility wherever it is possible.

Now, in regard to the details of State accretion of responsibility, that comes strictly under the act on the basis of contractual rights granted by the AEC, does it not?

Mr. TOWNSEND. That is my understanding.

Representative HOLIFIELD. In other words, the act is permissive. It does not confer within itself any authority independent of contract?

Mr. TOWNSEND. That is my understanding.

Representative HOLIFIELD. It is an enabling act?

Mr. TOWNSEND. That is right.

Representative HOLIFIELD. So any detail of responsibility which would be transferred would be contractual between the AEC and the State of New York?

Mr. TOWNSEND. The agreement will define what areas the Atomic Energy Commission is withdrawing from.

Representative HOLIFIELD. That is right.

Therefore, the Atomic Energy Committee sits in judgment upon the ability of the State to perform any function delegated to it in the signing of that agreement.

Mr. TOWNSEND. You mean the Commission.

Representative HOLIFIELD. The Commission, yes. Excuse me.

Mr. TOWNSEND. That is right. They have to make findings of competence and compatibility.

Representative HOLIFIELD. If there was some transfer from the State to the city of New York, for instance, this would undoubtedly be part of the original contract; that is, not specifically to that one city but it would grant that privilege to the State?

Mr. TOWNSEND. We intend to write all into the contract that our lawyers say is appropriate to include.

Representative HOLIFIELD. You have said that you want to do these things with the approval of the Atomic Energy Commission.

I want to talk to you for a moment about a site. Assume that the AEC grants a license for the building of a plant at X site in New York State, and let us assume that New York State might take the position that this was an unsafe site. Independent of contractual rights, do you take the position, or do you not, that New York State would have the veto right as a matter of inherent State authority for the setting up of an atomic energy plant although it had a license from the Federal Government?

Mr. TOWNSEND. What position we would take on that I would like to reserve until and unless such a situation arose. Then we would discuss that particular situation. We don't have any set policy.

Representative HOLIFIELD. It is a hypothetical question in a way, but it could be a very real problem. Under the State police powers, the different subdivisions of the State do have the right by ordinance to prohibit obnoxious or hazardous enterprises from their respective political boundaries.

Personally, I would hope that the State would exercise and exercise wisely the power of veto in case a site license was granted by the Federal Government. I believe in this one field—at least in this one field, there may be others—that the right of the people of a community to function should not be superseded by the Federal Government because it is not a matter of moral principle nor is it necessarily a matter of importance to the national defense.

Certainly there are hazards involved which I believe the local people should have the right of veto power in case there was a real, real substantial reason for their not wanting to go along with the Federal license.

Mr. TOWNSEND. It was this kind of thinking that led us to make the suggestion last year. Whether we would ever try to challenge the Federal Government on constitutional grounds is a question that I think is better for us not to worry about until a specific situation arises.

Representative HOLIFIELD. Possibly so, and I think there is possibly a diversity of opinion of the committee on this point. I was expressing my own opinion on that point.

I think your State should be complimented for the advance research you have done in this field and also in the field of civil defense against radioactive contamination.

Chairman ANDERSON. Are there other questions?

If not, thank you very much, Mr. Townsend. We are glad to have you appear before us.

Mr. TOWNSEND. Thank you, sir.

Chairman ANDERSON. Mr. Linsenmeyer.

STATEMENT OF JOHN C. LINSENMEYER, EXECUTIVE VICE PRESIDENT, AMERICAN RADIATOR & STANDARD SANITARY CORP.

Mr. LINSENMEYER. Thank you, Mr. Chairman.

Chairman ANDERSON. Will you state your position with American Radiator & Standard?

Mr. LINSENMEYER. I am John C. Linsenmeyer, executive vice president of American Radiator & Standard Sanitary Corp.

It is a pleasure and an honor to appear before your committee for the third time in as many years, to present the views of American-Standard on the development of the civilian atomic energy industry, specifically in regard to process heat and to advanced types of power reactors.

During the past year, we have all been impressed with the vigor and dispatch with which the Atomic Energy Commission and the Congress have proceeded with definite plans to construct new water-moderated reactors, among these, the experimental low temperature process heat reactor and the small size pressurized water reactor.

May I interpolate here, we are presently seeking the latter job and God grant we get it.

As a manufacturer of conventionally fueled process steam equipment, we are pleased to note that this area for application of nuclear energy is receiving increased interest and attention.

As a logical projection of the Commission's existing water reactors program, we believe that a low-cost process steamplant and a small low cost powerplant both of the boiling water type should be constructed respectively at the site of an industrial steam consumer and a small utility. A pressurized water reactor process steamplant is now planned by the AEC for Point Loma. This certainly is a step in the right direction. Equally important is the small-sized pressurized water reactor project in which we have great interest. However, we believe that a boiling water type may be cheaper for process steam and power for many applications. At least with the present state of cost accuracy the choice is not clear. In this regard we agree with Argonne National Laboratory and the Oak Ridge operations office as stated in their reports of costs of small pressurized water, boiling water, and organic cooled reactors. Only construction of equivalent boiling water reactors to determine costs can resolve this question.

Therefore, we believe that serious consideration should be given, in cooperation with industry, to the construction of a small boiling, natural circulation process steam reactor at an industrial plant where costs can be realistically appraised. The use of a carbon steel primary system and aluminum fuel cladding is recommended if the feasibility of these materials is confirmed by present experiments. Process heat users have testified before this committee as to their readiness to install such a plant, with appropriate economic support. We recommend a similar program for a small boiling water reactor powerplant.

On my last appearance here before you, I described our variable moderator boiling water reactor, now being developed under Commission support at our advanced technology laboratories division. Recent work on VMR kinetics has corroborated the finding of AEC laboratories that boiling reactors have the potential of operating with complete stability at very high power densities, economically advantageous to this application. Incidentally, the VMR is now in the critical experiment stage, and the results we have achieved to date are highly promising.

To summarize my comments on the water reactor program, we congratulate the Joint Committee and the Commission on the recent strides forward in this field. For the near future, we would strongly

advocate the construction of additional small process steam and power reactors under cooperative arrangements with industry.

In the area of other power reactor types, we urge that the level of research and development support for newer and theoretically promising reactor concepts be increased. Commendable as it is to cut back on developments when results have not borne out expectations, perhaps the pendulum has now swung too far and too fast away from advanced reactor development.

I say this for two reasons. The first is that, based on current extrapolation involving many millions of dollars of additional development and improvement work, all established reactor types seem to hit rock bottom in power generating costs at perhaps 7 or 8 mills per kilowatt-hour. This is just about the same as conventional power costs. The fuel cycle costs for these reactors can hardly be below 2 to 3 mills per kilowatt-hour. The capital costs cannot be much below the range $200 to $250 per kilowatt, which at 80 percent plant factor and 14 percent capital charge adds up to 5 mills per kilowatt-hour. Adding small charges for operating and maintenance, insurance, and so forth, puts the total at or above conventional costs for the major fraction of the utility industry. This, of course, will restrict the application of nuclear power to only high power cost regions.

Second, because of the lack of experience with nuclear plants compared with conventional plants, utility companies may not choose nuclear plants unless the nuclear plants have a clear advantage of 1 mill or more. Frankly, in view of the continued improvement in conventionally fueled plants, it is not certain that the established reactor type plants will show this needed clear economic advantage over conventional plants for many, many years.

If this is true, then any comprehensive reactor development program must include a significant amount of work on bringing more promising reactor types to early fruition. The discouraging results on materials of construction in certain past reactor experiments should not cause us to give up the chase. Rather, more care should be exercised in the future that a proper materials base exists, or will have been developed before the reactor experiment is constructed.

To illustrate the foregoing by drawing on our own experience, let me describe the advanced reactor type having minimal materials problems and yet showing promise of significantly reduced capital and fuel cycle costs. I refer to our fast breeder reactor cooled with boiling mercury, which we term the MCBR. Such a reactor could operate at 1,000° F., using commercially available low alloy steel for fuel cladding and structures. The justification for this last statement is that several conveniently fuel mercury turbine plants have been operating at these temperatures for years with essentially no corrosion.

Mercury turbine plants now in operation have no operating difficulties. However, the increased cost of mercury and the high efficiency of the reheat steam cycle make new conventionally fuel mercury turbine plants comparatively uneconomic. On the other hand, in a fast breeder nuclear plant, mercury as a coolant has advantages over other systems make it very attractive, we believe.

Our company, under the AEC new reactor concepts program, has conceived and designed this MCBR with exciting results. The use of boiling mercury eliminates many of the problems of breeders with

sodium cooling—the heavy shielding against sodium radioactivity, the intermediate heat exchanger and the high temperature steam generator, and the ever-present danger of sodium-water reaction. The mercury at an average temperatue of 920° F. goes directly to a mercury vapor turbine for producing electric power. Mercury vapor leaving the turbine is used to generate steam at 900° F., which is passed through a separate steam turbine to generate additional electricity.

The thermodynamic efficiency of this mercury dual cycle is 33.4 percent, appreciably higher than 30 percent for an equivalent sodium cooled (Fermi) plant. The capital costs are much lower than for the latter, and the fuel cycle costs, particularly on plutonium breeder cycle, also give promise of being quite low.

I have referred to this reactor as one of which we have personal knowledge and as representative of the type of concept which we believe bears further development—namely, new reactor types that can be built without an order of magnitude improvement in materials technology. There are undoubtedly other such concepts, and I urge the committee and the Commission to encourage their development to the fullest extent possible.

As a final suggestion to the committee, I urge the Government to facilitate the inclusion of operating utilities in reactor development contracts. I personally feel this is of utmost importance in the development of economic reactors. Under the present third-round ground rules, utilities can only participate in new Government-supported reactor developments if the utility agrees irrevocably to build a plant or agrees to accept severe penalty clauses regardless of how successfully the development proceeds. As I have discussed in former testimony before this committee, our large public utilities have a tremendous pool of experience in ways to cut power costs, which experience could be an important factor in achieving civilian reactor designs which would give us reliable low-cost service as central station plants. Also, by participating in the development of a new reactor concept, the utility could then make its own decision as to whether the concept was sufficiently attractive for construction. I believe that if the present rules were modified in this respect there would be substantially increased participation of utilities in the nuclear program.

Representative DURHAM (presiding). Thank you, sir.

Mr. LINSENMEYER. If I may, too, gentlemen, I might add informally that American-Standard is in this business with the intent and expectation of arriving at one or more standardized types of reactors that can be sold for process steam or small power generation. We are aiming really at the day when we can offer a guaranteed product with a guaranteed operating cost. Perhaps this will take some of the glamor and adventure out of nuclear work, but I believe when we get out a catalog of standardized reactors nuclear power will have arrived.

Thank you very much.

Representative DURHAM. Thank you very much, Mr. Linsenmeyer. This is an excellent statement. You bring out some points in your recommendations which I agree with; that is, you should encourage some new thoughts into this field.

Mr. LINSENMEYER. As I mentioned, I think we have swung a little too far away from the exotic and into the familiar. I think we should keep some stimulus on new and novel reactor types, not broadly diver-

gent from what we are doing or falling into the error again of designing types that require metallurgical progress that we have not reached as yet. The design or project should be tailored to available metallurgy.

Representative DURHAM. I think this committee has been very alert to that. We have not wedded ourselves to any particular type here. We have tried to cover the field as broadly as we could so we could get the experience and know-how from something besides pressurized water. It seems everybody now is going to pressurized water.

Mr. LINSENMEYER. It offers a degree of certainty, let me say.

Representative DURHAM. That is true.

Mr. LINSENMEYER. But it does not stimulate progress.

Representative DURHAM. But there is no reason why we should not make as much advance on other reactors as we have on that. We spent a lot of effort and time on that. Are there any questions?

Representative HOLIFIELD. Mr. Chairman, I certainly agree with you, Mr. Linsenmeyer, on what you said on page 3, that any program must include a significant amount of work on bringing more promising reactor types to early fruition. I also approve of your reference to the necessity of fast breeder development. I certainly think that it was pretty conclusively shown in the charts that Mr. Starr presented yesterday to us that a use of the fast breeder principle would actually magnify our existing stocks from a utility standpoint tremendously. By a factor of a hundred, at least.

Mr. LINSENMEYER. That is right. In fact, something of that sort is almost essential if you look into the future.

Representative HOLIFIELD. Yes. If you are going to keep the economics down, it certainly is true. Do you believe that this concept which you call the MCBR is at the stage now in technology where either a title 1 design study should be made of it, or would you go further?

Mr. LINSENMEYER. Yes, sir: aimed at building a prototype and trying it out.

Representative HOLIFIELD. A small reactor along the size of the Vallecitos or Santa Susana size.

Mr. LINSENMEYER. Yes, sir. It does not involve much in the metallurgical or attendant skills other than solving the unknowns of the basic fuel area itself.

Representative HOLIFIELD. Do you believe that there is enough mercury and it is cheap enough to use for this purpose?

Mr. LINSENMEYER. The quantities required are not what they were for conventional plants. In fact, some years ago the Public Service of New Jersey abandoned their mercury boiler and sold a million and a half dollars of mercury, but this was built back in the 1920's. There is no problem in the availability of mercury.

Representative HOLIFIELD. In other words, the quantities needed for this type of operation or a larger plant would not be as much as you utilize in the conventional plant.

Mr. LINSENMEYER. No, sir.

Representative HOLIFIELD. You feel that there would be enough of it available at a price that you could afford to use it?

Mr. LINSENMEYER. I do think so, Mr. Holifield.

Representative HOSMER. How much less is required here than in a conventional plant?

Mr. LINSENMEYER. You mean for equivalent kilowatt output?

Representative HOSMER. Yes. How many flasks of mercury or whatever unit you use?

Mr. LINSENMEYER. Pounds, let me say. I will give you a guess. Fourteen thousand pounds for a 10,000-kilowatt job, but we will confirm this in our written statement to the committee.

Representative HOSMER. What would a conventional 10,000-kilowatt modern design take?

Mr. LINSENMEYER. I have to picture the boiler——

Representative HOSMER. Twice as much?

Mr. LINSENMEYER. Twenty times as much, I would guess, at least.

Representative HOLIFIELD. I was going to inquire, do you have any figures on the stockpile of mercury?

Mr. LINSENMEYER. I don't.

Representative HOLIFIELD. Mr. Durham, we have a tremendous lot in the stockpile, do we not?

Representative DURHAM. Yes.

Representative HOLIFIELD. We have a stockpile of this mercury as one of our strategic metals.

Mr. LINSENMEYER. I know the price is very stable which indicates that there is a balance between demand and supply at the present moment.

Representative HOLIFIELD. Could I ask you if there is any appreciable loss in the utilization of this?

Mr. LINSENMEYER. You mean leakage from the system?

Representative HOLIFIELD. Yes.

Mr. LINSENMEYER. None.

Representative HOLIFIELD. In other words, it is not a material that you would use up in this kind of operation?

Mr. LINSENMEYER. No.

Representative HOLIFIELD. It is merely an inventory that would remain almost static.

Mr. LINSENMEYER. That is right. It is permanent. This plant still operating at Hartford, Conn., has not had to add any mercury for years. Literally they have not added a pound of mercury to it. It is sealed and the loss is next to zero.

Representative PRICE. One of the reasons they have not gone into so much in the use of mercury in the sodium-cooled plant is the fear of the toxicity.

Mr. LINSENMEYER. That has been one of the fears.

Representative PRICE. I don't say I subscribe to that, but isn't that one of the reasons?

Mr. LINSENMEYER. Yes, I think so. Before we went into this, as a matter of fact, we went around and consulted with the conventional mercury vapor plants that were in operation expecting to collect a long series of things to guard against and methods. We found to our surprise that there is no leakage problem. They don't have it.

Representative HOLIFIELD. You are not contemplating this MCBR to be a combination of sodium and mercury.

Mr. LINSENMEYER. No, just mercury.

Representative HOLIFIELD. That is what I thought. That is why I did not understand your question.

Mr. LINSENMEYER. Maybe I didn't understand it, either.

Representative PRICE. I thought you were using the mercury as a barrier on the sodium-cooled reactor.

Mr. LINSENMEYER. No. The reactor proper will be cooled with mercury and the mercury vapor will operate the turbine and then go through a heat exchanger.

Representative PRICE. My question is still pertinent because the incident I have in mind, which I don't care to discuss here, the reason they didn't use mercury in this particular project was the fear of leakage and toxicity.

Mr. LINSENMEYER. There has been some fear on that point. We found that in conventional powerplants it is not a problem as far as these people were concerned, and there is a number of mercury vapor plants operating with fossil fuel.

Representative PRICE. What about a propulsion plant?

Mr. LINSENMEYER. I don't know of any, Mr. Price.

Representative PRICE. I am thinking of one, but I won't mention it.

Representative HOLIFIELD. Would you submit to the committee a memorandum on this and go into a little more detail?

Mr. LINSENMEYER. I would be most happy to do so.

Representative HOLIFIELD. Give us your information as to the present state of the technology and what you estimate a title 1 study in this field would cost, and then what you would estimate a 5,000- to 9,000-kilowatt plant capital investment would be necessary when you reached the point of building it.

Mr. LINSENMEYER. I think we have much of this information available already, and we would be most happy to send it. Shall we address it to the chairman of the committee?

Representative HOLIFIELD. Yes, to the chairman of the committee. That would include the costs of an engineering design and the advantages that you feel would come to this type of a fast breeder reactor project.

Mr. LINSENMEYER. I would be very glad to do so.

(The material referred to appears on p. 382.)

Representative HOLIFIELD. There is nothing like that built now, is there?

Mr. LINSENMEYER. No, there is not. We are currently working on this under Commission sponsorship, which is the MCBR.

Representative HOLIFIELD. How far have you gone in your technology? To a critical assembly?

Mr. LINSENMEYER. To a point where at least our boys are bubbling over with enthusiasm. I can't tell you, Mr. Holifield. I will include a statement on the point of progress in this letter.

Representative HOLIFIELD. I would like to have that. What is your fiscal position? Are you at the point in your technology where you need to take another step or do you need more preliminary research and development work?

Mr. LINSENMEYER. Would you like me to introduce Mr. Nixon, our technician, on that?

Representative HOLIFIELD. It would be perfectly all right.

Mr. LINSENMEYER. Would you step up, please?

Representative HOLIFIELD. I agree with the basic principle that we have to get started on some of these reactor projects if we are going to have anything to start building on 3 or 4 years from now. There is going to be a gap as I see it in the number of these reactors that are going to be built and operating. If we don't have any preliminary work done on any new starts at all, we will have a hiatus of 3 or 4 years in which nothing will be done in the atomic energy field.

Mr. LINSENMEYER. No progress in overall efficiency or anything else. You have to get the stuff fed into the mill.

Representative HOLIFIELD. I am not speaking of the advanced types which are nearing on the on-line capability like your big pressurized water and boiling water and combinations of those two. I am thinking about other types such as you have suggested here which seem to be at the point in our technology where they need to take the next step. It is a modest step but it is an important step because it would involve the elimination of at least 3 years of delay if we don't do anything until we find out what some of the plants now being built will do from an operational standpoint. I doubt if the operational experience of a boiling water or pressurized water is going to solve the problems that you have here in this type, because this is such a radically different type.

Mr. LINSENMEYER. No. They will simply give us experience in operating a particular type and experience on the part of the people who supply components. They get more competent in building pressure vessels and they get cheaper as they learn to overcome difficulties. All we are doing is developing a skill on a very narrow band.

Representative HOLIFIELD. Are you ready to answer the question?

Mr. NIXON. Yes. We have completed the initial design work that the Commission requested on this concept.

Representative HOSMER. Will you tell us first how much work you have done in relation to mercury under conditions of reactor physics, chemistry, and temperatures in excess of 900 degrees and so forth? I think that it basic.

Mr. NIXON. Yes, sir.

Representative HOSMER. In that connection I recollect about 12 months ago somebody put out a study or an opinion that was quite adverse to the use of mercury in these things. If you recollect anything of that, you might discuss it at the same time. I just remember its existence.

Mr. NIXON. I will try.

We turned in a final report to the Commission on this.

Representative HOLIFIELD. When?

Mr. NIXON. We turned this in December. We have pending before the Commission a recommendation for a continuing research and development program on this, part of which is to clean up some of the work which we did in the areas of physics and kinetics. Then we want to continue research and development in the areas of heat transfer.

We also proposed a test reactor and a title 1 design of which you were speaking, and we feel we have gone about as far as we can go now. We spent approximately $150,000 of the Commission's money on this initial study. We feel we have gone about as far as we can

go until we take the next step, the research and development in the heat transfer and building.

Representative HOLIFIELD. Would you do this before you did your title 1 design?

Mr. NIXON. No, sir. We would want a title 1 design because this points the direction in which you should go with your test. This gives you the overall picture of what a plant can do and should do. Therefore you can more correctly orient the engineering of your test to meet the objective which your title 1 design points out you should meet. We think these things overlap. They certainly don't go in series or the program drags out too long.

We have this program pending before the Commission and we have received no word on it as to where it stands.

With regard to what we have done in the areas of physics and metallurgy, we have built, mainly at our own expense, a heat transfer loop using mercury in which we have extended the heat transfer capabilities or data on boiling mercury from what was considered in the past a limit of 200,000 B.t.u.'s per square foot to 600,000 B.t.u.'s per square foot. In other words, we have tripled the possibilities of transferring heat by mercury.

Representative HOSMER. Are you running it up by increasing temperature?

Mr. NIXON. Yes, sir. There is no question that we can go up a thousand degrees.

Representative HOSMER. Have you done this under conditions of radiation?

Mr. NIXON. No, sir.

Representative HOSMER. Have you done anything with mercury under conditions of radiation?

Mr. NIXON. Not to my knowledge. There has not been any experimentation directly under radiation circumstances. However, as is in the case with most liquid metals, including sodium and others, the effects of radiation are minimal, if these exist at all, since they are elemental substances which radiation does not affect primarily except activation. In the case of activation the products which mercury turns out, which gives you problems in the plant, are much less severe than with sodium. This is one of the major advantages. We can get in and repair and maintain our equipment much easier than you can in a sodium plant.

In addition, we boil mercury in the reactor itself under excellent heat transfer conditions, pass it directly to the turbine without an intermediate heat exchanger and return it back to the reactor in a condensed state. This has cut the capital costs, according to our estimate, of the nuclear plant by an order of one-half over the present Enrico Fermi plant. This, we feel, is a rather significant advance in the line of fast breeders.

Representative HOSMER. You say you boil it in the reactor?

Mr. NIXON. Yes, sir.

Representative HOSMER. Do you boil it in the fuel elements?

Mr. NIXON. Right around the fuel element.

Representative HOSMER. What kind of pressure do you run at?

Mr. NIXON. It is a couple of hundred pounds. That is all we have in the system. This is all that is required. The temperature is the key so far as thermal efficiency is concerned.

Representative HOSMER. Is there any particular problem with respect to fuel elements or is that pretty well standard?

Mr. NIXON. No, sir. As a matter of fact, the materials are available for mercury systems. The standard low alloy chrome molybdenum steels in present boilers are sufficient for use in nuclear systems. These are the chroloy steels. They are present boiler tube materials.

Representative HOSMER. What outlet temperature is there involved?

Mr. NIXON. Our present design is for about 960° F. We believe we can go up to the order of 1,200° F. without difficulty. We have operated our loop at those temperatures, and we don't see any problem.

Representative HOSMER. You were going to comment on the adverse criticism.

Mr. NIXON. I have been trying to think what it is.

Representative HOSMER. I can't think of what it is either, but if you are familiar with it, will you recollect it for us?

Mr. NIXON. I believe there was an article which came out in Nucleonics concerning some Russian work in mercury that they had performed. As I recall the problems may have been in the heat transfer area. But we feel we have solved those problems in the demonstration already in our test loop.

Representative HOSMER. This thing is not going to work unless you can incorporate breeding. I mean economically.

Mr. NIXON. Economically certainly breeding is a distinct advantage.

Representative HOSMER. Mr. Lisenmeyer, you mentioned present reactors at probably a minimum of 7 or 8 mills power cost. What is this for mercury in your mind?

Mr. LINSENMEYER. I will pass that on to Mr. Nixon. The estimates I have gotten from the boys is a potential of 1 to 1.5 mills under it. Is that right?

Mr. NIXON. That is for fuel cost. I will have to defer that question by saying we will have to compare the potential of this plant with what is presently being developed by the Commission, which is the sodium cooled.

Representative HOSMER. I am not anxious to spend a lot of money on this thing if it is going to be a little bit better, but not very much better. Better is a matter of degree.

Mr. NIXON. It cuts the capital costs in half, which is one of the major parts of cost.

Representative HOSMER. It cuts from 5 mills to 2½ mills.

Mr. NIXON. Yes.

Representative HOSMER. And the fuel cost is cut in half.

Mr. NIXON. The fuel costs remain about the same order as sodium.

Representative HOSMER. Then you bring it down to around five altogether, or four and a half.

Mr. NIXON. There is certainly a potential of that.

Representative HOSMER. You really don't think you are going to get it?

Mr. NIXON. I can't say that on the first plant this will happen. I say there is a potential for bringing fast breeders down into the range where they are economically feasible.

Representative HOSMER. Mr. Linsenmeyer, you mentioned in your testimony this difficulty we are having with metallurgy.

Mr. LINSENMEYER. Yes, sir.

Representative HOSMER. And ceramics and things like that. Everybody skirts around it all the time. You are the first man who had the courage to bring it up in this hearing that I recall. Instead of taking this fuel cycle mercury reactor and instead of taking a lot of these other programs that are trying to push beyond the state of the art, do you feel we should take that money and just put it into a metallurgy, ceramics, and materials program and run at a high pace on that for 2 or 3 or 4 or 5 years, and then see what we have to work with?

Mr. LINSENMEYER. I think there can be a certain amount of concurrent activity in that. If we are going to make an essay into a mercury steam cycle such as we are talking about, you will have to tailor your design of this cycle to the available metallurgy. Certainly, Mr. Hosmer, I think all we could put into exotic metallurgy should be put into it.

Representative HOSMER. I am wondering whether we should take some money out of these other programs and put it in there. We run up against materials barriers in ANP and this field and that field and all fields. The progress is not going to be very rapid in it. It is a long and difficult problem.

Mr. LINSENMEYER. I realize that.

Representative HOSMER. One of the reasons is, you yourselves look around for work done on mercury and found no one had done any for a long time. You just happen to get hot on mercury, so you happened to get into the field. If you had not, probably there would be much less knowledge about it today. It illustrates that selection of materials research area comes by chance rather than by programing.

Mr. LINSENMEYER. We don't like to feel it is completely by chance.

Representative HOSMER. Maybe we should have an overall program and spend some money. You just don't know?

Mr. LINSENMEYER. I believe, Mr. Hosmer, that we should concurrently carry forward other reactor designs.

Representative HOSMER. I know we should do a lot of things concurrently. But we don't have enough money to "concurrent" all the time. Thus there comes a problem of what should come first in the sequence.

Mr. LINSENMEYER. I agree with you that a slice of funds should be taken from somewhere and invested in metallurgy.

Representative HOSMER. Thank you.

Representative DURHAM. That has been needed for a long time.

Mr. LINSENMEYER. Yes.

Representative HOLIFIELD. May I ask about your reference to using commercially available low alloy metal for cladding in the structures?

Mr. NIXON. Yes, sir.

Representative HOLIFIELD. Why is it that you can use that when we have so many troubles with other elements using fuel cladding?

Mr. NIXON. Most of the other difficulties we are having in the other systems metallurgically speaking is due to the coolants used in regions where technology has not been developed. In the mercury system we are not extending those frontiers. We are using mercury at temperatures which have been used for years and materials which have been developed some time ago for that particular application. The mercury system was introduced in the 1920's, and there was a great deal of expenditure of money to develop alloy materials suitable for mercury. That has been done. By plan, we like to feel, we looked at this as a coolant that gave us the temperatures in a fast breeder system which is within current practice, and which materials have been developed for, because we recognize the problem of metallurgy. We came up with a plant which surprised us at its savings in cost. This is the reason we are able to use that. We approached the problem initially trying to do that and we came up with mercury as a logical answer to this.

Representative HOLIFIELD. If you have any way of getting away from some of these metallurgical problems, that would be good. That is why I went along with this idea of Dr. de Hoffmann in the General Dynamics project, although I realize that the first idea for a plant is not going to put it into effect apparently. It was with the idea of circumventing in some way or another these terrible metallurgy problems which we have, which are seemingly insoluble.

Representative HOSMER. I don't know whether Mr. Nixon knows he is going to have metallurgical problems with this or not.

Mr. NIXON. We are not extending this to any areas in the power experience that we have not had experience with for years and years, except radiation. All our experience with liquid metals to date——

Representative HOSMER. I remember 30 years ago Popular Mechanics had a cover of the first one they built up in New England, and it was real fantastic, and I was much interested in it.

Mr. NIXON. They have opened that system not too long ago, and they have found the original machining marks are in the tubes. There has been practically zero corrosion in some 30 years of the use of mercury plants. So we are really not facing that kind of problem. What we are facing here is a demonstration in a nuclear plant of using mercury. We have investigated all the problems that we feel are important at this point. We feel we are ready to launch into the next phase which is a Title 1 design and a subsequent test of this thing as an actual demonstration somewhere. We think this is a great step forward in the fast breeder business. I think this is the reason we are quite enthused about it.

Representative HOLIFIELD. I think you presented some very interesting thoughts here, and some challenging concepts, particularly in this field of getting around the metallurgical problems we are having in several other devices. I trust that you will furnish us some more material along this line so we can study it.

Mr. NIXON. Yes.

Mr. LINSENMEYER. We certainly will.

Chairman ANDERSON (presiding). Thank you very much.

Mr. LINSENMEYER. Thank you, Mr. Chairman.

(The material referred to on p. 376, together with a letter from the AEC concerning the MCBR, follows:)

ADVANCED TECHNOLOGY LABORATORIES,
DIVISION OF AMERICAN-STANDARD,
Mountain View, Calif., March 8, 1960.

Hon. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Washington, D.C.

DEAR SENATOR ANDERSON: Members of your committee requested additional information on our mercury-cooled breeder reactor program, following a description given by Mr. John C. Linsenmeyer, executive vice president of our corporation, before the committee on February 24. We appreciate this opportunity to present this information to you, as we consider this program of great promise in the achieving of the national goal of economic nuclear power. The following documents are enclosed in compliance with your request:

1. A summary of the current status of the MCBR program and the potential of the reactor type.
2. The evaluation report submitted to the Commission in December 1959 (ATL–A–102).
3. A proposed program for the future development of the MCBR (ATL P–1035).

Since our appearance before your committee, we have received an answer from the Commission on the above-mentioned proposal. In lieu of the complete program as proposed, the Commission has requested us to submit a proposal to do a small amount of additional work covering the kinetics of this reactor system. It is our intention to comply with the Commission's request, and more kinetics information is certainly of importance. However, as we have indicated to the Commission, we remain of the opinion that this new concept is sufficiently attractive to warrant planning for and initiation of a more extensive program, namely one which will permit a much earlier realization of its potential. Indeed, we feel that the program we originally proposed could be initiated now, as it included the kinetics work suggested by the Commission plus those additional tasks required at this time to realize an early construction date.

It is pointed out that the total cost of the development program leading to and including the design of a 100-electrical-megawatt prototype powerplant of the MCBR type is estimated to be less than $10 million. The capital cost savings alone realized by constructing a mercury-cooled breeder reactor in lieu of a sodium-cooled breeder reactor of the 100-electrical-megawatt size is considerably more than this figure. Thus, we feel that the development program as originally submitted is well worth while.

American-Standard's interest in this project is exemplified by its own support of experimental work in this area. As was pointed out during our testimony, we have constructed and operated small scale heat transfer experiments which have already extended the technology for mercury systems by a factor of three. Thus far we have found no limit experimentally to the possibilities of high performance from mercury systems. We have also continued our design investigation of the MCBR system, and have concluded that a direct cycle shows even greater promise than the indirect cycle which was the basis for our work under Commission contract.

We have made a preliminary projection of MCBR costs into the future, so as to compare the potential of this system with other reactor types indicated in the Commission's 10-year program. The potential cost for the MCBR of 7.3 mills per kilowatt-hour obtained under the same ground rules as the Commission's own estimates, compares quite favorably with the Commission's projected 7.5 mills per kilowatt-hour for sodium-cooled breeder plants. The cost of a program to realize this potential in the MCBR appears to be but a small fraction of that postulated by the Commission to achieve the potential of a sodium-cooled system. Indeed, in its own evaluation of fast breeder reactors, the Detroit Edison Co. concluded that a major area for potential improvement is the "development of a primary coolant that satisfies plant requirements better than sodium." Mercury as a primary coolant definitely appears to satisfy plant requirements better than sodium, since it is far less hazardous, entails less equipment, gives higher thermal efficiencies, and is backed by years of existing plant technology.

As was stated in the testimony, our work is based on existing materials technology. Lack of consideration of this point has been perhaps the major cause of discouragement with many of the new reactor concepts on which considerable research and development funds have been expended to date without realizing the anticipated results. With such a firm basis for this new concept, we recommend that the mercury-cooled breeder reactor form an integral part of the Commission's overall program for the development of an economic fast breeder power system.

If there are any questions on the enclosed material, we would be pleased to answer them at your convenience.

Yours very truly,

E. J. WILSON, JR., *President.*

(An excerpt from enclosure No. 1, noted above, follows. Enclosures Nos. 2 and 3 are on file with the Joint Committee.)

A SUMMARY OF THE AMERICAN-STANDARD MERCURY-COOLED BREEDER REACTOR PROGRAM

As the result of a proposal by American-Standard in August 1958,[1] the U.S. Atomic Energy Commission has sponsored, under the new reactor concepts program, a technical and economic evaluation of a highly promising new reactor type. This new type reactor is a fast breeder reactor cooled by boiling mercury and is characterized by:

1. Fissioning and breeding with high-energy (fast) neutrons.
2. Low pressure and high temperature utilizing boiling mercury as a coolant, thus permitting the use of a well-known and highly developed technology for powerplant applications.
3. Existing and commercially available materials and plant components.
4. Low capital cost and ease of maintenance and operation.

The mercury-cooled breeder reactor (MCBR) evaluation investigated technical feasibility based on criteria established by the Commission and American-Standard and developed a conceptual reactor and powerplant design. The design was completed in sufficient detail to provide a realistic basis for a preliminary economic evaluation. Capital costs, fuel-cycle cost, and operating and maintenance costs were estimated, and the results compared with published data regarding similar costs for a sodium-cooled fast breeder reactor powerplant system. A detailed account of the technical feasibility, plant design, and economic analysis of the MCBR based on an indirect cycle is presented in American-Standard report ATL–A–102, copies of which have been submitted to the staff, Joint Congressional Committee on Atomic Energy. The conclusions drawn from this evaluation are summarized as follows:

1. A mercury-cooled breeder reactor (MCBR) is feasible and economically promising.
2. A substantial reduction in capital cost and an increase in efficiency are realized over the sodium-cooled system, especially if a direct cycle is used, employing a mercury turbine binary cycle.
3. Based on conservative estimates, the fuel-cycle costs for the MCBR compare favorably with sodium-cooled systems.
4. Equipment and materials requirements can be met with present technology.

In addition to the evaluation, heat transfer experiments have been carried out by American-Standard which have verified that the high heat transfer rate required by nuclear applications are attainable with boiling mercury.

REACTOR POWERPLANT DESCRIPTION

In a boiling mercury breeder reactor, the reactor core consists of metallic, partially enriched uranium fuel elements clad with a low-alloy steel which is and has been available commercially in large quantities for many years. The fuel elements are cooled with mercury which is allowed to boil in the core. It has been experimentally demonstrated by American-Standard that the very low density liquid-vapor mixture of mercury which is produced in the core can

[1] "A Proposal To Evaluate a Fast Breeder Reactor, Using Boiling Mercury as a Coolant," p. 471.

sustain very high rates of heat removal without the danger of overheating that is commonly experienced with other boiling reactor coolants.

The power generating portion of the plant consists of either:

1. An indirect cycle, in which the mercury vapor exchanges its heat in an intermediate heat exchanger to produce steam which is passed through a steam turbine, or

2. A direct cycle, in which mercury vapor passes directly to a mercury vapor turbine. Low-pressure mercury vapor leaving this turbine is in turn used to generate steam which produces additional electric power in a steam turbine.

The first frontispiece shows a pictorial representation of an indirect-cycle mercury-cooled breeder reactor; the second frontispiece shows a direct-cycle plant schematic, while the third is an external view of an overall MCBR plant. Simplified flow diagrams of both cycles are shown in figures 1 and 2.

In the indirect cycle, no mercury enters the turbine. This procedure is equivalent to replacing the sodium in a sodium-cooled plant with boiling mercury. Superheated steam at about 900 degrees F. is produced for use in a conventional steam turbine-generator plant.

Evaluation work to date has been based upon the indirect cycle, thus permitting a direct comparison with sodium-cooled systems. However, the indirect cycle places the mercury system at great disadvantage in such comparisons. The direct, or binary cycle has many economic and operating advantages. It is the one currently in use in conventionally fueled mercury powerplants. Hence, a great deal of mercury technology and handling experience is available for this application. Sufficient work has been done by American-Standard on this cycle to indicate its technical feasibility.

The radiation activity problem with mercury is orders of magnitude less severe than with sodium, since the gamma rays found are weak and of short half life. Also, the ever-present fire hazard of sodium is completely eliminated. There is no reaction with water or air as is true in sodium systems. Hence, the direct cycle promises a beautiful simple powerplant of extremely high thermal efficiency, which could result in as much as a 30-percent increase in electric output per unit of precious fissionable naterial consumed.

In the direct cycle, mercury vapor is passed directly from the reactor to a mercury turbine, then condensed by the generation of stream, which in turn passes to a stream turbine. Greatly improved thermal efficiency is achieved by expanding the mercury vapor through a turbine before it is condensed to produce lower temperature steam. Thus the two intermediate heat exchangers of the sodium-cooled system are eliminated and replaced by one lower temperature mercury-to-water steam generator.

It is usually, but incorrectly, believed that mercury toxicity caused the widespread use of the mercury-cycle powerplant to be curtailed. The actual cause was the economic disadvantage occasioned by an increase in the cost of mercury occurring simultaneously with improvements in steam-cycle economics through technological development. Since a direct steam cycle cannot be used in fast breeder reactor systems, mercury is definitely more attractive for breeder reactor plants than for conventional powerplants.

COSTS

The estimated costs of producing power in the MCBR are shown in tables I and II. In table I, the MCBR costs for a conservatively designed first prototype power reactor equivalent to the Enrico Fermi may be compared with similar costs for other reactors when they were in approximately equivalent stages of development. Even at this early stage of the MCBR program, the lower capital cost advantage is apparent. Lower capital costs are a result of the simple, low-pressure system, the low-cost container material, the minimal shielding requirements of activated mercury, and the chemical compatibility of mercury with air and water. Fuel costs show little difference from the initial estimates of the sodium-cooled Enrico Fermi plant.

The potential for market reductions in the total power cost for the MCBR that would result from an orderly development of the concept are apparent in table II. Here, projected designs for the MCBR plant are compared with similar projected designs for sodium-cooled breeders as prepared by the Detroit-Edison Co. and by the AEC. The plutonium cycle is utilized in all of these

plants rather than the U^{235} cycle. Note that in all comparisons with the sodium-cooled breeder reactor power costs, the MCBR has significantly reduced capital costs, resulting in a marked decrease in total power cost. Note also that a total power cost of 7.3 mills per kilowatt-hour is estimated as a projected cost for a large plant on a basis equivalent to that used in the Commission's 10-year program forecasts. Credit is taken for the foreseeable advantages as indicated in the various MCBR cases. The 7.3 mills per kilowatt-hour power cost compares favorably with the cost of power from conventionally fueled plants in all but the lowest fuel-cost areas.

The cost estimates presented in the tables are based on a plutonium value of $12 per gram and a fissionable material inventory charge of 4 percent per annum. The standard AEC fixed-charge rate of 14 percent per year was used, which includes Federal and local taxes and insurance other than third party liability insurance. A breakdown of these charges is presented as table IX in the final report on the MCBR evaluation, ATL–A–102. A plant load factor of 80 percent was assumed for all cases. Net station efficiencies for the direct-cycle mercury systems were estimated from existing data.[2] The operating and maintenance costs developed in the MCBR evaluation were used for all the 100-megawatt (electrical) MCBR cases, and the value was arbitrarily halved for the larger reactor size.

TABLE I.—*Comparison of estimated power costs in large first-generation U.S. nuclear power stations*

Station—Reactor type	Dresden—boiling-water	Yankee—Pressurized-water [3]	Hallam—Sodium graphite	First prototype sodium-cooled plant (Enrico Fermi)—Sodium-cooled fast breeder	First prototype MCBR [1]—Mercury-cooled fast breeder (indirect cycle)
Net power, megawatt (electrical)	180	110	75	100	100
Net station efficiency, percent	28.7	28	31.2	31.3	33.4
Plant cost, dollar/kilowatt	$400	$470	$670	$570	$328
Power cost, mills per kw-hr: [3]					
Capital charges	8.0	9.4	13.3	11.3	6.6
Fuel costs	4.4	6.4	3.8	12.0	13.3
Operating and maintenance	2.1	2.1	1.0	2.0	1.5
Total	14.5	17.9	18.1	25.3	21.4

[1] These data are based on the conservative design considerations that are nominally adopted for the first plant of such a new and advanced type. The data are also based on the indirect cycle per the Commission's request.

[2] The Shippingport reactor was the first large pressurized-water power reactor installed in the United States, but power costs were so high (64.4 mills/kw.-hr.) that the Yankee reactor at Rowe, Mass., affords a more realistic cost comparison.

[3] Power costs were calculated from information available in published references.

[2] Thompson Ramo Wooldridge Engineering Bulletin, vol. 3, No. 1, March 1958.

TABLE II.—*Estimated MCBR costs from projected designs*

	Present		Future					
			MCBR				Sodium-cooled breeders	
	MCBR reference design	Enrico Fermi	I [1]	II	III	IV [2]	Detroit-Edison [3]	AEC [4]
Cycle	[5]	[5]	[5]	[6]	[6]	[6]	[5]	[5]
Power level, megawatt	100	100	100	100	300	300	340	300
Net station efficiency, percent	33.4	31.3	33.4	40	40	48	32	----
Maximum mercury or sodium temperature, ° F	1,000	1,010	1,000	1,000	1,000	1,300	830	----
Fuel reprocessing	[7]	[7]	[8]	[5]	[8]	[8]	[5]	[7]
Fuel	U^{235}	U^{235}	Pu^{239}	Pu^{239}	Pu^{239}	Pu^{239}	Pu^{239}	Pu^{239}
Plant cost, dollar/kilowatt	$328	$570	$328	$294	$189	$170	$265	$222
Power cost, mills/kilowatt-hour:								
Capital costs	6.6	11.3	6.6	5.9	3.8	3.4	5.5	4.4
Fuel-cycle cost	13.3	12.0	5.9	4.9	4.9	2.6	1.5	2.0
Operating and maintenance	1.5	2.0	1.5	1.5	0.8	0.8	0.8	0.8
Reprocessing plant	----	----	0.5	0.5	0.5	0.5	0.5	----
Total:								
MCBR	21.4	----	14.5	12.8	10.0	7.3	----	----
Sodium-cooled reactor	----	25.3	----	----	----	----	8.3	[9] 7.5

[1] Case I represents the design produced for the USAEC new reactor concepts program. The reference design was modified to incorporate plutonium instead of uranium fuel.
[2] Fuel-cycle costs reflect the increased power density permitted by elevating the mercury temperature; oxide fuel is required.
[3] Data are from M. C. Beekman and R. E. L. Stanford, "A Preliminary Evaluation of Large Fast Breeder Reactor Power Plants," The Detroit Edison Co., NPDD–3, August 1958.
[4] Data are from "Civilian Power Reactor Program, Part II—Economic Potential and Development Program as of 1959," USAEC, December 1959.
[5] Indirect.
[6] Direct.
[7] Offsite.
[8] Onsite.
[9] Total includes an insurance cost of 0.25 mill per kw.-hr.

PROGRAM

These highly attractive aspects of the mercury-cooled breeder reactor concept have led American-Standard to formulate a program aimed at the eventual design and construction of a commercially feasible MCBR powerplant. This program was submitted to the Atomic Energy Commission as American-Standard proposal P–1035 on August 28, 1959. The program consists of the following three phases:

A. Phase I

Phase I includes a title 1 design and detailed cost estimate, kinetics evaluation and hazards analysis, and an evaluation of several fuel-element and core configurations that offer promise for improved performance.

B. Phase II

Phase II consists of an experimental boiling heat transfer program to obtain engineering data, thus permitting the design of optimum core configurations, using the highest attainable heat transfer performance.[3] This phase also includes a zero power experiment to insure appropriate loading in reactor test core and to verify the kinetics and control characteristics.

C. Phase III

Phase III includes an MCBR reactor test which will be designed and built to serve as a final demonstration of feasibility and to provide operating data for the detailed design and construction of the first prototype powerplant. Note that no materials program is envisaged.

Figure 3 shows an estimate of the schedule and cost of the proposed program, while a more detailed account is given in P–1035.

It is apparent from the total of less than $10 million that the cost of the program leading to and including the design of the first 100-megawatt prototype power MCBR is less than one-half of the capital cost saving accrued over a 100-megawatt sodium-cooled reactor powerplant.

It is believed that the foregoing information supports the conclusion that this reactor concept is deserving of a significant place in the Commission's fast breeder reactor 10-year planning. American-Standard is prepared to undertake this program immediately.

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., March 23, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy, Congress of the United States

Subject: Advanced Technology Laboratories' proposal for further R. & D. of the mercury-cooled breeder reactor.

DEAR MR. RAMEY: This is in response to your telephone request to Mr. Staebler on the above subject.

The proposal that was offered to me was for $1,037,000, which we consider phase II work in the new reactor concepts program. I rejected this because more study is needed, particularly in reactor kinetics, before a decision can be made as to the attractiveness of this reactor concept.

In other words, we consider that phase I is not yet complete. Therefore, we asked ATL to propose physics studies to provide the remaining information required to evaluate the concept. We expect this proposal to be for about $50,000, and we are prepared to support this physics work if the proposal is satisfactory.

Sincerely yours,

FRANK K. PITTMAN,
Director, Division of Reactor Development.

Chairman ANDERSON. Our next witness is Mr. Lindseth. Will you proceed, please?

[3] American-Standard at its own expense has continued work in this area, with excellent results.

STATEMENT OF ELMER L. LINDSETH, CHAIRMAN, EDISON ELECTRIC INSTITUTE COMMITTEE ON ATOMIC POWER, ACCOMPANIED BY MR. KEARNEY

Mr. LINDSETH. Thank you, Mr. Chairman.

Chairman ANDERSON. Mr. Lindseth, you have been with us many times. Will you state who you are representing in this presentation for the record?

Mr. LINDSETH. Yes, sir. Mr. Chairman, my name is Elmer L. Lindseth. I am president of the Cleveland Electric Illuminating Co., and chairman of the Edison Electric Institute Committee on Atomic Power. The institute represents 195 operating companies serving 97 percent of all customers of the investor-owned segment of the utility industry in the United States. These customers comprise 77 percent of our Nation's electric users.

It is in behalf of the Edison Electric Institute that I am testifying here today. This statement has been authorized by the institute's committee on atomic power, the makeup of which is attached. We appreciate the opportunity to be heard.

INVESTOR-OWNED UTILITY PROGRAM

The Nation's electric utility companies are today actively engaged in a broad and diversified industry program for the development of economically competitive nuclear power.

Three nuclear powerplants in which investor-owned electric companies are participants are in operation; 11 company sponsored projects are under construction, design or contract; and 3 are in the planning stage, of which 2 are in active negotiations. The 14 projects that are either in operation under construction or under contract involve utility company expenditures of $485 million and embrace 6 different reactor types. In total, these 17 nuclear power projects will involve utility expenditures of some $650 million and aggregate some 1,800,000 kilowatts.

Chairman ANDERSON. Could you tell us how many kilowatts are under construction?

Mr. LINDSETH. Yes. We have that in the appendix. Mr. Kearney, our staff man, will get that figure for us.

Should I proceed, sir?

Chairman ANDERSON. Yes.

Mr. LINDSETH. Utilities are also participating in nine other nuclear research, development, and study projects, involving substantial expenditures. Some of these will no doubt lead to additional reactor construction projects. As of the end of 1959 utilities have spent on these and the previously mentioned nuclear power projects approximately $230 million. This is about 50 percent more than the year-end 1958 cumulative figure. This large increase is due mainly to construction expenditures during the year for several large nuclear plants. In all, 132 utilities are participating in these programs. These companies and the various utility projects are listed in appendix I.

PROGRESS DURING PAST YEAR ON UTILITY PROGRAM

During the past year an additional electric utility company-sponsored project was announced, one large power reactor attained initial criticality, and major progress was achieved on other nuclear projects already underway.

Consumers Power Co. announced it will build a 50-megawatt high power density, boiling water reactor powerplant for 1962 operation. At present Consumers Power Co. and General Electric Co., equipment manufacturer for the project, are negotiating a contract with the Atomic Energy Commission for certain research and development. The utility applied for a construction permit early this year.

The 180-megawatt Dresden nuclear powerplant attained criticality on October 15, 1959. Construction is complete. The fuel loading program, including necessary testing, is now in progress after some normal startup difficulties were experienced. The project is expected to be ready for full operation by the middle of 1960. The Yankee project also is expected to be in operation in the latter part of 1960. Construction of the Enrico Fermi project is expected to be essentially complete by October 1960. Insertion of fuel and low power testing will begin shortly thereafter. About 1 year of low to full power testing is scheduled.

During 1959 the AEC modified its contract with Northern States Power Co. and Central Utilities Atomic Power Associates to include an internal nuclear superheater for the Pathfinder project. The Commission also signed contracts with Philadelphia Electric Co., Carolinas Virginia Nuclear Power Associates, Inc., and East Central Nuclear Group-Florida West Coast Nuclear Group. The two latter groups, plus Northern States Power Co. and Pacific Gas & Electric Co. also applied for construction permits during the year. The Saxton Nuclear Experimental Corp. signed a contract with Westinghouse Electric Corp. and recently was granted a construction permit by AEC.

The Indian Point nuclear powerplant is 60 percent complete and is expected to be in operation by 1961. Preparatory fieldwork on the Pathfinder plant began in 1959 and construction on this plant, the Parr Shoals plant of CVNPA, and the Humboldt Bay plant of Pacific Gas & Electric Co. is scheduled to start early in 1960.

The utility industry continued to obtain valuable experience from the three reactor projects operating on utility systems—Shippingport, Vallecitos, and Santa Susana.

In the field of thermonuclear research a project jointly sponsored by the Texas Atomic Energy Research Foundation and General Dynamics is going into its third year.

During the year the seven major electric power companies in New York State formed an organization to investigate the most efficient and economic means of supplying the future electric power needs of the State. Among other things the group, known as Empire State Utilities Power Resources Associates, has begun a continuing study of nuclear power so that future decisions for major thermal powerplants on the New York State integrated electric system will give full consideration to the feasibility and the economics of nuclear powerplants.

Details on all the projects and a listing of the participating companies are shown in the appendixes.

Five utilities and Davidson Chemical Division of W. R. Grace and Co. formed the Industrial Reprocessing Group to undertake a study of the technical and economic feasibility of the design, construction, and operation of a privately owned facility for the processing of spent nuclear fuels. The five utilities are: Commonwealth Edison Co., Consolidated Edison Co. of New York, Inc., the Detroit Edison Co., Northern States Power Co., and Yankee Atomic Electric Co.

NATIONAL POLICY OBJECTIVES

As we have heretofore testified, the Edison Electric Institute concurs in the nuclear power policy objectives proposed by the Chairman of the Atomic Energy Commission last year and reaffirmed by him last week. These objectives, namely, to reduce the cost of nuclear power to competitive levels in high fuel cost areas of this country within this decade, to assist friendly nations to do likewise somewhat sooner, and to maintain U.S. world leadership in the peaceful applications of nuclear energy, are of vital importance to the Nation's electric utility industry.

For this reason we are devoting substantial resources of manpower, experience, organization, and financial support to the successful attainment of these objectives.

We wish to point out, however, as we did at last year's hearings, that—

Healthy, ultimate utilization of atomic energy will only take place with electric power companies, manufacturers of equipment and other interested industries working together, without the requirements of special restrictions, special forms of assistance and the extent of direction by Government, which presently exists.

The role of Government required during the transition period to economic nuclear power should not be allowed to perpetuate Government's activities in the nuclear power field or to hamper the participation of private industry in the civilian nuclear power program. Full utilization of our industrial complex is needed if we are to attain the goal we have set for ourselves.

Hence, we again propose a fourth objective, as we did at last year's hearings, that the development of nuclear power be brought as soon as possible and as nearly as possible within the framework of commercial development of conventional energy sources.

To fulfill this objective, we urge that greater use be made of the facilities of private industry in all phases of our nuclear power program, i.e., power generation, fuel reprocessing, general research and development, etc. Our country's nuclear power policy objectives will be attainable at minimum cost to the taxpayer when the cost-cutting incentives and initiatives of industry are utilized to their maximum.

PROGRAM TO FULFILL NATIONAL POLICY OBJECTIVES

Developments during the past year reaffirm our belief that emphasis should continue to be placed on research and development with actual plant construction carried out at a rate consistent with research achievements. Events of the year also reconfirm the need for intensified fuel element technology research and engineering.

Prototype reactor plants should be built to demonstrate the technical feasibility and economic merits of promising new reactor concepts or modifications. Large-scale reactors of any type generally should be installed only when there is reasonable assurance that a sponsoring utility system can produce electric power from the proposed nuclear plant substantially competitive with power generated from a similarly sized conventional unit in the same area. Necessity for excessive extrapolations from a prototype plant in designing the large-scale plant or assumptions concerning its operations and economics are not in accord with good utility practices, probably justify the conclusion that the type of reactor under consideration is not yet ready for large-scale construction. In such a case, it would be preferable to spend the equivalent money and manpower required for the project on more research, development, and engineering in the prototype stage. In fact, these tests of reasonableness of assumptions and the degree of extrapolation should be applied at every stage in the development of reactor concepts.

There is no general agreement that any one reactor or class of reactors is superior to all others. For this reason we believe that we must necessarily continue to investigate a number of reactor concepts. The utility industry is today building, designing, or investigating six different reactor types. But as has been pointed out before, a commitment to investigate a concept should not imply that the development must be continued to the ultimate construction of a large scale plant or even a prototype plant. Reactor concepts with inadequate promise of ultimate success should be dropped or deferred in favor of more promising concepts.

Continuous evaluations of reactor types should be made and our experience utilized to establish engineering and cost criteria. However, we caution against any program that is unduly rigid and any policy formulated on the basis of specific and inflexible target dates. The program for achieving our objectives should be continually reevaluated from time to time in the light of prevailing conditions and technical progress. Adequate provisions should be made for individual decisions and efforts outside the framework of any interim Government program. Unsolicited projects for new power reactor concepts proposed by industry in furtherance of the objectives should not only be accepted but also encouraged. As we pointed out in our testimony last year, rigidity in the program may impede adequate exploitation of new developments.

Chairman ANDERSON. Before you start the next section, will you go back to the previous page and relate that last paragraph to what is going on in the British and in the General Dynamics-Philadelphia Electric gas-cooled reactor?

Necessity for excessive extrapolations from a prototype plant in designing the large-scale plant or assumptions concerning its operation and economics that are not in accord with good utility practices, probably justify the conclusion that the type of reactor under consideration is not yet ready for large-scale construction.

In the *General Dynamics-Philadelphia Electric* case, there is certainly a vast area that is just plain extrapolation. There is no reactor or prototype for that reactor, is there?

Mr. LINDSETH. That is my understanding.

Chairman ANDERSON. Would you be in favor of building the Philadelphia plant or rejecting that?

Mr. LINDSETH. I am in favor of the program as it is presently in progress at Philadelphia; namely, to do the ultimate job in two steps; to wit, step one with metal-clad fuel elements based on which experience will be achieved for the ultimate impervious graphite-clad elements. This is a two-step program with very extensive research and development.

Chairman ANDERSON. That is still a jump, isn't it?

Mr. LINDSETH. Yes, it is. It is technically a very advanced reactor.

Chairman ANDERSON. That reactor is to cost about $40 million. Are you familiar with the figures on how much the Government is going to put into it?

Mr. LINDSETH. My impression is $14.5 million of research and development as between the AEC and General Dynamics.

Chairman ANDERSON. No, that is all Government money.

Mr. LINDSETH. That is Government money, plus probably normal waiver of fuel charges.

Chairman ANDERSON. That is not all. In addition to that, there is a lot of money that is research and development from the private utilities that is 52 percent Government money.

Mr. LINDSETH. I don't believe it is 52 percent Government money if it is utility money.

Chairman ANDERSON. Is that so?

Mr. LINDSETH. I don't think the Government has any rights to money until it is earned.

Chairman ANDERSON. You mean if they don't use that money, they don't pay it to the Government in taxes. I happen to know a company in which some people I am associated with have a little interest, and they are making a contribution to various reactors. If they did not make that contribution, wouldn't that money be available for taxation? I am trying to find out how much of this money is Government money. I don't regret it, because I voted for this project enthusiastically. You have dampened my ardor a little bit. You say they should not be built and you should not have excessive extrapolations and that was the very point that Dr. De Hoffmann made when he presented the plan to me. He brought it to my hometown a year ago and pointed out this did represent a very advanced extrapolation, but gave us a chance to take a very large jump ahead of the rest of the world. On that basis I thought it was a good idea.

Mr. LINDSETH. I concur.

Representative HOSMER. Mr. Chairman, may I ask another question on the same section? I keep hearing about Texas utilities thermonuclear program all the time but nobody hears what it is or how much money is being spent. Do you have any idea what they are doing?

Mr. LINDSETH. Yes, I think we have. Could I defer the answer to the question until we look it up so we may give you a precise statement?

Representative HOSMER. Yes, of course.

Chairman ANDERSON. In this project Dr. Teller is the consultant for General Dynamics, isn't he?

Mr. LINDSETH. I am not familiar with the internal General Dynamics organization on it.

Chairman ANDERSON. Are you familiar with Project Turret?

Mr. LINDSETH. No, sir; I am not.

Chairman ANDERSON. I was wondering if you thought Project Turret was in any way connected with the gas-cooled reactor development?

Mr. LINDSETH. I am not familiar enough with the details to have an opinion.

Chairman ANDERSON. It is an expenditure of Government money on the very thing that would be needed to make the gas-cooled reactor work.

Representative HOLIFIELD. As I understand it, your testimony is against that type of assistance by the Government.

Mr. LINDSETH. And the specific type is what?

Representative HOLIFIELD. Against the type of assistance which is in this sentence that the chairman has just questioned you about, the necessity for excessive extrapolations from a prototype plant or assumptions concerning its economics that are not in accordance with good utility practices probably justifies the conclusion that the type of reactor under consideration is not yet ready for large-scale construction. So you would be against that type of assistance by the Government?

Mr. LINDSETH. If the project under consideration were large scale in the sense we are currently using the term, that is of the order of two or three thousand kilowatts, we wouldn't favor it. But I think in the Philadelphia case we are talking somewhat less.

Representative HOLIFIELD. You should use large scale in the context of the steps that preceded it, and there have been no steps that preceded this at all. This is a large step for a new type which has not had the preliminary experimental and prototype development. It goes into about a $40 million project. Of course, you don't rate that altogether on kilowatts. You rate it on the history of the type of reactor. You have just explained that such a type of reactor would not yet be ready for large-scale construction.

Mr. LINDSETH. We may be using prototype in a different sense from the one you now describe. In the sense we are using the term, it describes the Philadelphia Electric reactor and we consider that to be a prototype.

Representative HOLIFIELD. You say if its operation and economics are not in accord with good utility practices it would probably justify the conclusion that it was not ready to be built. We have gone ahead and put up a total of $16 or $17 million in fuel waiver and in direct research from the Government on that. I would have to come to the conclusion that you would be against that type.

Mr. LINDSETH. We didn't intend that, Mr. Holifield, because we do not consider the Philadelphia reactor to be what we are here calling large-scale construction. We consider it a prototype and it is the kind of a reactor project which we endorse, namely, to confine our engineering, development, and research efforts to reactors of that character and not move to the 250,000- or 300,000-kilowatt size if they require excessive extrapolation.

Representative HOLIFIELD. Then you are in favor of Government assistance on that size?

Mr. LINDSETH. Yes, we are.

Representative HOLIFIELD. On page 6, you say:

> Unsolicited projects for new power reactor concepts proposed by industry in furtherance of the objectives should not only be accepted but also encouraged.

Is this what you mean by encouraged, that the Government should put up some of the money on research and development?

Mr. LINDSETH. Yes.

Representative HOLIFIELD. How do you reconcile that with page 4, where you quote what you said last year, where you said:

> We wish to point out, however, as we did at last year's hearings, that "Healthy ultimate utilization of atomic energy will only take place with the electric power companies, manufacturers of equipment, and other interested industries working together, without the requirements of special restrictions, special forms of assistance, and the extent of direction by Government which presently exists.

What do you mean by the special forms of assistance?

Mr. LINDSETH. The type you are describing. We look on the present period as a transition period to what we hope will ultimately be a commercial industry able to operate without the special assistance of Government, and the special direction from Government, and that the peaceful generation of nuclear power will take its place alongside coal-burning plants or oil-fired burning plants as a normal operation.

Representative HOLIFIELD. The committee has always taken the position that the ultimate goal is economic plants. Some of us have felt that a transition period in which these encouragements and special assistance were justified. I wanted to be sure you are not condemning that principle.

Mr. LINSETH. We are not; no. We look forward to the day, as you said the committee does, when this will take its normal commercial place.

Chairman ANDERSON. Since he has gone back to that sentence, you mentioned two large reactors that are in the negotiation stage. One of them may have to do with Pacific Gas & Electric, and one may have to do with Southern California Edison. It is my understanding that in both those instances there would need to be substantial amounts of money in the nature of Government research and development still required, possibly as much as 6 to 8 million on each one. Would you think that was a special form of assistance?

Mr. LINDSETH. Yes. I would think that would be a special form of assistance.

Chairman ANDERSON. And you would not favor that?

Mr. LINDSETH. No, I don't believe we have said that in this transition period we would not favor that. But we look forward to the day when ultimately it won't be needed.

Chairman ANDERSON. I look forward to it, too, but I am still trying to read the English language.

> Healthy ultimate utilization of atomic energy will only take place with electric power companies, manufacturers of equipment, and other interested industries working together, without the requirements of special restrictions, special forms of assistance, and the exent of direction by Government which presently exists.

Mr. LINDSETH. The key to what we are intending by the sentence is the word "ultimate."

Chairman ANDERSON. I just wanted to be sure that if I voted for $6 million to help GE or Westinghouse on these things I was not going to have the U.S. Chamber of Commerce against me.

Mr. LINDSETH. I can't speak for the chamber of commerce.

Chairman ANDERSON. But you can for the institute and it will be all right. You will give us a badge of courage on that to go ahead. I frankly think that we ought to do it and put up some money. I have said so and believe so still.

Mr. LINDSETH. We will resume near the bottom of page 6, the present and future status.

The institute believe that progress to date in the U.S. program of civilian nuclear power development has been both substantial and adequate on the basis of all domestic considerations. And in the light of recent developments abroad, it also is clear that our progress is adequate to meet the requirements of friendly nations there.

Developments in England, Europe, and Russia all indicate that the immediate need for nuclear powerplants abroad is not as pressing today as anticipated a year or two ago.

These developments abroad emphasize the reduced worldwide interest in uneconomical large-scale nuclear reactor plants. Our domestic nuclear power development program recognizes this and is moving ahead as rapidly as economics and our national objectives require.

Our industry is confident of the ultimate economic use of nuclear energy for the production of electricity and has, therefore, invested in nuclear power projects amounts substantially in excess of the equivalent cost of conventional plants. Recently, in reply to a request of the U.S. Senate Select Committee on National Water Resources, the Edison Electric Institute submitted estimates of how the future loads of the investor-owned segment of the electric utility industry will be served. The estimates indicated that about 7,700,000 kilowatts of nuclear capability will be in use by 1970, and about 38,900,000 kilowatts by 1980 under the conditions assumed in this report. Appendix No. VI summarizes the nuclear power estimates submitted to the select committee. Further data bearing on the point are in the records of that committee.

Mr. RAMEY. How many plants does that contemplate by 1970?

Mr. LINDSETH. Can we put it together from data we have?

Mr. KEARNEY. I think it would be difficult.

Chairman ANDERSON. I may be wrong, but I thought the Edison Electric Institute material submitted to the select committee was pretty good. It was not based on plants. It was based on demand and total national demand and it showed that a percentage of that might be developed from nuclear energy. I don't believe you broke it down into individual plants.

Mr. KEARNEY. We did not break it down into individual plants, but types of generation, hydro, nuclear, and so forth.

Mr. RAMEY. If you divided that by 200 megawatts for each plant, that would be 35 or 40 plants. That is a lot of plants by 1970.

Mr. LINDSETH. Yes, it is.

Mr. RAMEY. Compared to what the Commission has in its 10-year program, and even its optimum ideas on getting down to 7-mill power.

Mr. LINDSETH. Possibly it would be helpful if we submitted as a supplement to this statement a brief section that I don't have with me

from the report to the select committee which describes these tables and the conditions under which the assumptions were made. We will file that by supplement.

Chairman ANDERSON. Will you do that, please? We will insert it in your testimony at this point, because I think it is interesting.

(The information referred to follows:)

EDISON ELECTRIC INSTITUTE,
New York, N.Y., February 25, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy, Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: * * *

I have enclosed the additional information Mr. Lindseth indicated he would supply to you. This information consists of the breakdown according to project status of the total kilowatts in the utility industry's nuclear power program and the reference made to nuclear power in the Edison Electric Institute report to the Select Committee on National Water Resources.

* * * * * * *

You will note that the section on nuclear power taken from the select committee report shows total capability and estimated expenditure figures that are different from those that are shown in Mr. Lindseth's "202" statement. The addition of the Southern California Edison Co. project and an increase in capacity for the Pacific Gas and Electric Co. project (200 to 300 megawatts) account for the differences.

Sincerely,

JOHN J. KEARNEY,
Secretary, Committee on Atomic Power.

NUCLEAR POWER

(From Edison Electric Institute report submitted to Select Committee on National Water Resources, January 1960)

The expected installation of nuclear capacity by 1970 and 1980 in the several regions by the investor-owned systems was shown in table V. Because of the present state of the art, any long-range forecast must necessarily be speculative. The industry is aware of the importance of developing this new form of energy as rapidly as it is feasible to do so. Evidence of this is the participation of so many of the investor-owned utilities in the development of nuclear projects now in various stages of study, design, construction, and operation. One hundred thirty-one of these companies are engaged in this effort. The projects in which electric power companies are presently participating will have an ultimate combined capacity of about 1,400,000 kilowatts and will require an estimated expenditure by the companies of more than $570 million on these projects alone.

Exerience gained from these projects should provide by 1965 a better perspective for future development. In the absence of this experience, the industry can only rely on its best judgment and the views of authorities in the field. The national objective of our country is to achieve competitive nuclear power in the higher cost fuel areas of the United States within 10 years. The investor-owned utility industry subscribes to this objective. Many new and improved designs of nuclear plants are under development. Fuel for such plants is also being improved. However, the cost of power is still high, but the margin over fossil fuel power is narrowing. The rate at which nuclear power will gain on fossil fuel is difficult to predict but the estimates in table V are based on the best opinions available at the moment.

By 1970 about 7,700 megawatts of nuclear capability is projected for use in serving the loads of the investor-owned utility systems. This will represent about 3 percent of 1970 total capability projected by the investor-owned systems. Similar estimated figures for 1980 are 38,900 megawatts of nuclear capability representing about 8 percent of the total investor-owned capability in service.

As would be expected, substantial amounts of nuclear capability will probably be installed in the high fossil-fuel cost sections of the country. For example, in 1970 it is expected that about 7 percent of the investor-owned capability in the New England area will probably be nuclear. By 1980 this percentage is expected to be 16. Comparable percentages of nuclear capability in region VIII are expected to be 5.2 percent in 1970 and 19.2 percent in 1980.

Should future development increase the competitive position of nuclear power, nuclear capability would merely displace future projected conventional thermal capacity and have only an insignificent influence on hydro development.

Until nuclear plants are developed for and operated at higher steam pressures and temperatures, they will require somewhat greater amounts of cooling water. However, ultimate comparable steam conditions will probably be achieved.

Nuclear power program of investor-owned utility companies (status as of Feb. 15, 1960)

In operation on utility systems (or capable of operation)

Project number [1]	*Project*	*Capacity in kw.*
1	Shippingport	60,000
2	Vallecitos	5,000
3	Santa Susana	7,500
	Total	72,500
Under construction, design or contract		
4	Dresden (critical October 1959) [2]	180,000
5	Indian Point (construction 60 percent complete)	[3] 275,000
6	Pathfinder (preparatory field work started 1959)	66,000
7	Humboldt Bay (construction to start in April 1960)	50,000
8	Fermi (construction scheduled for completion October 1960)	100,000
9	Yankee (in operation 1960)	134,000
10	Parr Shoals (construction to start, spring 1960)	17,000
11	ECNG–FWCNG (research and development underway)	50,000
12	Peach Bottom (contract signed with AEC)	40,000
13	Saxton (construction to start early 1960)	5,000
14	Big Rock Point (construction scheduled April 1960)	50,000
	Total	967,000
In various planning stages		
15	New England Electric System	[4] 200,000
16	Pacific Gas & Electric Co	[5] 300,000
17	Southern California Edison Co	[6] 300,000
	Total	800,000

Total utility program	*Kw.*
In operation	72,500
Under construction, design, or contract	967,000
In various planning stages	800,000
Total	1,839,500

[1] Project number refers to identification used in Edison Electric Institute 202 statement.
[2] Status of project taken from Edison Electric Institute 202 statement.
[3] Includes capacity of fossil-fueled superheater. To obtain only total nuclear capacity subtract 135,000 kw. from total capacity figure resulting in total nuclear capacity of 1,704,500 kw.
[4] Listed in Edison Electric Institute 202 statement as 200,000 to 300,000 kw.
[5] Listed in Edison Electric Institute 202 statement as 300,000 kw. or larger.
[6] Listed in Edison Electric Institute 202 statement as approximately 300,000 kw.

Chairman ANDERSON. I want to say that I thought there were some logical assumptions in the material submitted to the select committee, but compared to the 10-year program of the Atomic Energy Commission, it looks very ambitious. However, one man's guess is probably as good as another's on what might happen in 10 years.

ROLE OF GOVERNMENT AND INDUSTRY

Mr. LINDSETH. Where Government participation is required temporarily in the civilian nuclear power program it should be a constantly diminishing one in keeping with the principle set forth in section 1 of the Atomic Energy Act of 1954, namely, to maximize participation in, and ownership of, facilities by private enterprise. It is, of course, recognized that during this transition period it may be necessary that the AEC supplement industrial research and development. But the AEC should confine its civilian nuclear power activities to fostering research and development and investigating promising reactor concepts. It should, to the maximum extent possible, use the services of private industry for research and development projects, reactor experiments, and the construction and operation of prototype reactors. All large-scale nuclear powerplants should be constructed, owned, and operated by operating utilities, either individually or in groups.

In order to fulfill properly this ultimate objective of our national program, Government assistance should be continued for both projects proposed by the AEC and unsolicited projects proposed by the utility industry.

ROLE OF MANUFACTURING INDUSTRY

The Atomic Energy Act of 1954 permitted industry for the first time to engage in its own nuclear-power activities. Private industry understandably was undeveloped in the nuclear field at that time and not adequately equipped to carry the major burden of developing competitive nuclear power. But today the manufacturing industry's capability to perform this function is available in most aspects. These capabilities should be used. Only when specific facilities do not exist in industry should Government-owned facilities be used. Not only should the AEC favor privately owned facilities in attempting to satisfy our national policy objectives in this field, but it should also encourage and sponsor independent research and development. AEC, among other activities, should encourage the industrial development of fuel-reprocessing facilities, including financial assistance, if necessary.

ROLE OF THE UTILITY INDUSTRY

The utility industry should construct, operate, and own all large-scale power reactors. The circumstances under which large-scale reactors should be built have been stated earlier in this testimony. Prototype power reactors also should preferably be constructed, operated, and owned by the utility industry.

Utilities are singularly qualified to test the operating ability of power reactors on interconnected utility systems. Thus, the ultimate goal of competitive nuclear power can best be reached at minimum cost if maximum use is made of the facilities of the utility industry.

RELATIONSHIP OF AEC TO UTILITY INDUSTRY

In a truly free enterprise system, as a matter of principle, there is no proper place for Government ownership of commercial-type

power reactors. The AEC should not own reactors on any utility system, whether investor owned or otherwise. If a reactor concept has reached a stage in its development when it becomes essential to construct a reactor plant capable of generating electricity, such a project preferably should be built by the utility industry with such AEC financial and other support as is necessary to bring the project to fruition.

Representative HOLIFIELD. How can you say that, when it is evident from the history of this whole art that it was necessary to build Shippingport at Government expense? That is on a utility system. It has been necessary to build Consumers of Nebraska because private industry would not pick up the ball and build those plants.

Mr. LINDSETH. At the time Shippingport was authorized, it is my understanding it could be built in no other way because it preceded the Atomic Energy Act of 1954, and could not have been owned by an electric utility system.

Representative HOLIFIELD. How about consumers of Nebraska, and Santa Susana, and Elk River?

Mr. LINDSETH. I think Santa Susana was initially authorized as a recator experiment to be built by the Commission and, later, power-generating facilities were added. In the case of Elk River, it would be my recollection that it is a second-round project offered only to a cooperative system.

Chairman ANDERSON. You don't say. You say the AEC should not own reactors or any utility system.

Mr. LINDSETH. We don't believe, in our industry, that in a free enterprise economy such as exists in the United States there is any proper place for the U.S. Government to own power-generating reactors or any utility system. We just do not believe that.

Chairman ANDERSON. Whether it is round 1, 2, or 10, you just don't believe in Elk River?

Mr. LINDSETH. No; we do not believe in Elk River.

Chairman ANDERSON. That is what I thought. You do not believe in Consumers Power of Nebraska.

Mr. LINDSETH. We do not.

Chairman ANDERSON. You don't believe in the one that is going to be built at Oak Ridge?

Mr. LINDSETH. No; we do not.

The institute is of the opinion that the current program underway is substantial and, when continued, will be adequate to meet the domestic objectives of our national nuclear-power program. Under the present world conditions, we believe it also will meet the international objectives of our program. Substantial utility industry resources, manpower, organization, and financial support are today being devoted—and will continue to be devoted—to the achievement of the Nation's objectives in the development of nuclear power.

Finally, we believe that maximum progress in the U.S. effort can be obtained at minimum expense to the taxpayer by pursuing our objectives within the framework of our free enterprise system.

I request to have filed with the record the six appendixes attached to this statement, which are a material part of it. Again, I would like to express the appreciation of the Edison Electric Institute for this opportunity to appear before your committee.

(The material referred to appears on p. 404.)

Mr. LINDSETH. Two questions are unanswered as of the moment. One is the first question of the chairman, the portion of the 1,800,000 kilowatts which are presently under construction, and the figure is 805,000 kilowatts.

Chairman ANDERSON. The reason I questioned it was just, if I can read the language over again, because you say the 14 projects that are either in operation, under construction, or under contract involve an expenditure of $485 million. In total, these 17 nuclear-power projects will involve utility expenditures of some $650 million and aggregate some 1,800,000 kilowatts. That was the figure that worried me, the 1,800,000 kilowatts, because I had once tried to total up the number of projects that are either constructed or under construction or under contract. If you will submit a list that totals up 1,800,000, I would be interested in seeing it, because I am afraid you are going to have to include things that are not in operation, under construction, or under contract.

Mr. LINDSETH. There are 14 projects which are in operation, under construction, or under contract.

Chairman ANDERSON. You include Consolidated Edison as 275,000 kilowatts, and it is only 145,000 nuclear. The rest is conventional steam.

Mr. LINDSETH. Yes; it has a fossil-fired superheater.

Chairman ANDERSON. So, we take 130,000 off that list. We can go on from there and find the ones that are under contract, not under contemplation now.

Mr. LINDSETH. If the semantics of the definition here would require that Indian Point would be rated only 145,000 within the context of the way we are speaking, we would reduce our totals by 130,000 kilowatts for the capacity of the fossil-fired superheater at Indian Point.

Mr. RAMEY. That would be included in your figure of 805,000 under construction.

Mr. LINDSETH. Yes. Indian Point is rated 275 in our table.

Mr. RAMEY. But not in that 800,000 figure that you gave us. It would be rated at 145 there?

Mr. LINDSETH. No; it would be rated 275.

Mr. RAMEY. Then you would have to lower that.

Mr. LINDSETH. Yes; we would lower that to be speaking in the same terms.

Chairman ANDERSON. That gives us 670,000; 670,000 is quite different from 800,000. How will you bridge the gap? We have been talking about missile gaps. Now, let us get to a power gap. There are 3 classes of reactors in the total of 17 we are describing. The number that we just added up for you are those presently under construction. You can name them by name. There are not so many of them.

Mr. LINDSETH. They are Dresden, Indian Point, Pathfinder, Humboldt Bay, Fermi, and Yankee. They total either 805,000, by our use of the term or 675,000 by the revised term.

Then we have under contract but not under construction Parr Shoals, Florida-West Coast, HTRDA—that is Philadelphia-General Dynamics—Saxton, and Consumers, which total 162,000 kilowatts.

Chairman ANDERSON. So, 685 plus 162 is a total of 847. Now, I have a million more to find.

Mr. LINDSETH. We have in operation Santa Susana, Vallecitos, and Shippingport.

Chairman ANDERSON. Is Santa Susana in operation?

Mr. LINDSETH. In the sense that it has operated; whether it is today or not, I am not informed. We had it rated 7,500 kilowatts.

Chairman ANDERSON. That is not worth worrying about.

Mr. LINDSETH. Vallecitos is 5,000, and Shippingport is in these figures at 60,000. I think it probably could be rated higher.

Chairman ANDERSON. That is 72,000, and that would bring you up to 910,000 or something like that.

Mr. LINDSETH. Then, of reactors planned——

Chairman ANDERSON. No; under contract now. They have to be under contract.

Mr. LINDSETH. The 17 reactors differ from those you describe. There are 3 plants in operation, 11 under construction, design, or contract, and 3 in the planning stage. The total is 17.

Chairman ANDERSON. We are going to add 300,000 for Pacific Gas & Electric, 300,000 for Southern California Edison, and what else?

Mr. LINDSETH. And 200,000 for New England Big, so called. It is the aggregate of all of those that make a total of 17.

Chairman ANDERSON. I do point out to you that I don't believe there has been any action by the board of directors of Southern California Edison or of Pacific Gas & Electric to sign any contracts with Westinghouse or GE on these.

Mr. LINDSETH. That is our understanding, as well.

Chairman ANDERSON. There are days when Mr. McCone, who has worked valiantly in this field, has been disappointed at the outlook.

Mr. LINDSETH. We have information in the appendixes contributed by both Southern California and P.G. & E. which state the status of their projects.

Representative DURHAM. Are there any further questions?

(Discussion off the record.)

Mr. RAMEY. I was under the impression in your testimony last year that your group was not necessarily opposed to the Government constructing these so-called experimental prototype plants, particularly where private industry had not expressed an interest in constructing a plant of that type, as in the case of this gas-cooled reactor at Oak Ridge. Although you might not be exactly cheering about it, you would, if this would fill a technological need, not necessarily object to it.

Mr. LINDSETH. I think that fairly states our position today.

Mr. RAMEY. That is a little different than just saying you are opposed to it.

Mr. LINDSETH. We deplore the end result, and we think that they preferably should be done another way. But the condition of your question was that if, technologically, it is indeed a required step, it obviously should not be passed up for lack of acceptance of an invitation.

Representative PRICE. Mr. Chairman, I would like to ask for clarification of the leadoff paragraph on page 5 of your statement, where you say, "To fulfill this objective, we urge that greater use be made of the facilities," and so forth. Are there any restrictions now in regard to this that would hamper private industry in these particular

items that you mention here? What were you thinking of there? There is no restriction against the utilities in the matter of power generation, fuel reprocessing, general research and development. Can't you do those things now?

Mr. LINDSETH. This paragraph is broader than public utilities alone.

Representative PRICE. That is the reason. I asked for clarification. I wanted to know what you were thinking of.

Mr. LINDSETH. This embraces the concept of the place of the normal commercial suppliers to our industry, the turbine manufacturers, the boiler manufacturers, and now reactor manufacturers, where in general we believe that the ultimate best objective will be achieved when work now being done in Commission facilities will be done in normal commercial facilities existing in industry, whether they be research, development, or manufacture.

Representative PRICE. That is why I asked clarification of the paragraph. I can't understand it. The power generation is done in most part by private industry, isn't it?

Mr. LINDSETH. There is some power generation on Commission installations, such as the gas-cooled reactor at Oak Ridge, and there is no existing commercial fuel reprocessing. A study is just being undertaken.

Representative PRICE. Are there any restrictions against commercial fuel-reprocessing plant?

Mr. LINDSETH. I am not expert in the field, but my impression is that it could be developed as a commercial enterprise.

Representative HOLIFIELD. As a matter of fact, the Commission has tried to get private industry into the fuel reprocessing for years and private industry cannot afford to do it, because up to this time the amount of fuel processing is so small and the cost of the plant to do the job is so large that all of it is done at tremendous loss. Therefore, if we are going to process the fuel from Commonwealth and Dresden and the rest of these privately built plants, this is part of your subsidy. The Government is not charging, and has never charged, the cost on fuel reprocessing or in waste disposal. These are all subsidies that are being given to private industry at this time in order to help you on this job of development. This has been offered to private industry, fuel reprocessing. Great efforts have been made by the Commission to get this done by private industry, but it just simply is not economic.

Representative PRICE. The point I wanted to bring out is whether or not there are any restrictions now against all this being done by private industry if private industry desires to enter the field.

Mr. LINDSETH. I think, as Mr. Holifield points out, the restrictions have been basically economic.

Representative PRICE. That is the reason I wanted the paragraph clarified.

Mr. LINDSETH. We hope the effort will be continued and ultimately there will be an industrial complex built up that can perform this service.

Representative DURHAM. You don't see the point where the Government will be out of this fuel business because of our security for weapons?

Representative HOLIFIELD. We have to do it for the fuel rods that come from our weapons plants, such as Hanford, Oak Ridge, and others. Therefore, having this large establishment we can probably do the fuel reprocessing in such small amount as there is from industry a lot cheaper than industry can do it itself.

Representative PRICE. The reason I ask the question is because you said we urge that greater use be made of the facilities of private industry. The reason I asked for clarification is because I want to know if we are ready for that or not. You say you don't think they are because it is a matter of economics. How can we make greater use of it now, the economics of the program being what they are? I am not attempting to argue with you.

Mr. LINDSETH. The sentence describes three phases of this effort, after the "i.e.", to wit, power generation, fuel reprocessing, and general research and development. They are widely different in the facilities available today to bring them about. Power generation we have described. If we go to the last, general research and development, we get to the generalized question that I think the chairman posed with regard to farming out research from Commission facilities to industrial facilities to the extent they can be utilized to carry on general research and development. Fuel reprocessing, which you have brought up, is as pointed out by Mr. Holifield today, able to be done only in the Commission facilities, because of lack of commercial facilities. A study is underway and mentioned in this report to determine whether it would be feasible to do that in industry, and we hope that the day will come when the fuel reprocessing industry can be a normal commercial industry.

Representative PRICE. The Commission has frequently urged industry to enter into this program.

Mr. LINDSETH. We hope that effort will continue even to the point of financial assistance to bring it about.

Representative BATES. That will be along the lines of the recommendations of Mr. Townsend today when we talked about fuel reprocessing and waste disposal and that type of thing.

Mr. LINDSETH. We would be hopeful on fuel reprocessing that it would not be a State sponsored facility but an industry sponsored facility.

Representative BATES. He did not say whether it would be owned by the State. He said within the State.

Mr. LINDSETH. Yes. We would be hopeful of that.

Representative BATES. I presume that he meant some Government assistance.

Representative HOLIFIELD. If you will yield, in his report to the State he did advocate a State donation to this facility. However, this was not accepted. It was a recommendation of the study committee but not necessarily accepted by the Governor.

Representative BATES. What you have in mind is a weaning away from the Federal Government more to the local area conducted by industry in conjunction with some aid.

Mr. LINDSETH. Yes.

Representative DURHAM. Let us put it another way. Suppose as of today, do you know any other way to do this job except under the licensing system?

Mr. LINDSETH. I would be sure it would have to be pretty carefully licensed, and have all of the normal accounting procedures for special materials.

Representative DURHAM. I realize there is a lot of redtape in securing licenses. That has been one of the complaints. But I think it has worked fairly well so far. I don't know how many have been granted since the 1954 act, but there have been quite a large number of them. We made an effort to get this done by private enterprise.

Thank you very much.

Mr. LINDSETH. Thank you, sir.

Representative DURHAM. We will meet tomorrow again at 2 o'clock in the Old Supreme Court Room, P–63 of the Capitol.

(The material referred to on p. 400 follows:)

APPENDIX I

ELECTRIC UTILITY COMPANY PARTICIPATION IN NUCLEAR POWER DEVELOPMENT—STATUS AS OF FEB. 15, 1960

NAMES OF ELECTRIC UTILITY COMPANIES PARTICIPATING IN NUCLEAR POWER STUDY, RESEARCH, DEVELOPMENT, OPERATING, AND CONSTRUCTION PROJECTS

Projects in operation

1. Duquesne Light Co. (Shippingport)
2. Pacific Gas & Electric Co. (Vallecitos)
3. Southern California Edison Co. (Santa Susana)

Projects under construction, design or contract

4. Commonwealth Edison Co. (Dresden)
   Nuclear Power Group:
   - American Electric Power Service Corp.
   - Central Illinois Light Co.
   - Commonwealth Edison Co.
   - Illinois Power Co.
   - Kansas City Power & Light Co.
   - Pacific Gas & Electric Co.
   - Union Electric Co.

5. Consolidated Edison Co. of N.Y., Inc. (Indian Point)
6. Northern States Power Co. (Pathfinder)
   Central Utilities Atomic Power Associates:
   - Central Electric & Gas Co.
   - Interstate Power Co.
   - Iowa Power & Light Co.
   - Iowa Southern Utilities Co.
   - Madison Gas & Electric Co.
   - Mississippi Valley Public Service Co.
   - Northern States Power Co.
   - Northwestern Public Service Co.
   - Otter Tail Power Co.
   - St. Joseph Light & Power Co.
   - Wisconsin Public Service Corp.

7. Pacific Gas & Electric Co. (Humboldt Bay)
8. The Detroit Edison Co. (Enrico Fermi)
   Potomac Electric Power Co.
   - Alabama Power Co.
   - Central Hudson Gas & Electric Corp.
   - Cincinnati Gas & Electric Co.
   - Columbus & Southern Ohio Electric Co.
   - Consumers Power Co.
   - Delaware Power & Light Co.
   - Detroit Edison Co.
   - Georgia Power Co.
   - Gulf Power Co.
   - Iowa-Illinois Gas & Electric Co.
   - Long Island Lighting Co.

Mississippi Power Co.
Philadelphia Electric Co.
Potomac Electric Power Co.
Rochester Gas & Electric Corp.
Toledo Edison Co.
Wisconsin Electric Power Co.

9. Yankee Atomic Electric Co. (Yankee):
Boston Edison Co.
Cambridge Electric Light Co.
Central Maine Power Co.
Central Vermont Public Service Corp.
Connecticut Light & Power Co.
Hartford Electric Light Co.
Montaup Electric Co.
New Bedford Gas & Edison Light Co.
New England Power Co.
Public Service Co. of New Hampshire
Western Massachusetts Electric Co.

10. Carolinas Virginia Nuclear Power Associates, Inc. (Parr Shoals):
Carolina Power & Light Co.
Duke Power Co.
South Carolina Electric & Gas Co.
Virginia Electric & Power Co.

11. East Central nuclear group; Florida West Coast nuclear group:
Appalachian Power Co.
Cleveland Electric Illuminating Co.
Columbus & Southern Ohio Electric Co.
Dayton Power & Light Co.
Indiana & Michigan Electric Co.
Indianapolis Power & Light Co.
Louisville Gas & Electric Co.
Monongahela Power Co.
Ohio Edison Co.
Ohio Power Co.
Pennsylvania Power Co.
Potomac Edison Co.
Southern Indiana Gas & Electric Co.
West Penn Power Co.
Florida Power Corp.
Tampa Electric Co.

12. Philadelphia Electric Co. (Peach Bottom); High Temperature Reactor Development Associates, Inc.:
Alabama Power Co.
Arizona Public Service Co.
Arkansas Power & Light Co.
Atlantic City Electric Co.
Baltimore Gas & Electric Co.
California Electric Power Co.
Central Illinois Electric & Gas Co.
Central Illinois Light Co.
Central Illinois Public Service Co.
Central Louisiana Electric Co., Inc.
Central Power & Light Co.
Cincinnati Gas & Electric Co.
Cleveland Electric Illuminating Co.
Delaware Power & Light Co.
Detroit Edison Co.
Gulf Power Co.
Gulf States Utilities Co.
Hawaiian Electric Co., Ltd.
Idaho Power Co.
Illinois Power Co.
Iowa Public Service Co.
Kansas City Power & Light Co.
Kansas Power & Light Co.
Kentucky Utilities Co.
Louisiana Power & Light Co.

Mississippi Power Co.
Mississippi Power & Light Co.
Missouri Public Service Co.
Montana Power Co.
New Orleans Public Service, Inc.
New York State Electric & Gas Corp.
Niagara Mohawk Power Corp.
Pacific Gas & Electric Corp.
Pacific Power & Light Co.
Pennsylvania Power & Light Co.
Philadelphia Electric Co.
Portland General Electric Co.
Potomac Electric Power Co.
Public Service Co. of Colorado.
Public Service Co. of New Mexico.
Public Service Co. of Oklahoma.
Public Service Electric & Gas Co.
Puget Sound Power & Light Co.
Rochester Gas & Electric Corp.
St. Joseph Light & Power Co.
San Diego Gas & Electric Co.
Sierra Pacific Power Co.
Southern California Edison Co.
Southwestern Electric Power Co.
United Illuminating Co.
Utah Power & Light Co.
Washington Water Power Co.
West Texas Utilities Co.

13. Saxton Nuclear Experimental Corp. (Saxton):
Pennsylvania Electric Co.
Metropolitan Edison Co.
Jersey Central Power & Light Co.
New Jersey Power & Light Co.

14. Consumers Power Co. (Big Rock Point)

Projects in various planning stages

15. New England Electric System.
16. Pacific Gas & Electric Co.
17. Southern California Edison Co.

Study, research, and development groups

18. Atomic Power Development Associates:
Alabama Power Co.
Baltimore Gas & Electric Co.
Central Hudson Gas & Electric Corp.
Cincinnati Gas & Electric Co.
Cleveland Electric Illuminating Co.
Connecticut Light & Power Co.
Consolidated Edison Co. of N.Y., Inc.
Consumers Power Co.
Delaware Power & Light Co.
Detroit Edison Co.
General Public Utilities Corp.
Georgia Power Co.
Gulf Power Co.
Hartford Electric Light Co.
Indianapolis Power & Light Co.
Jersey Central Power & Light Co.
Long Island Lighting Co.
Metropolitan Edison Co.
Mississippi Power Co.
New Jersey Power & Light Co.
New York State Electric & Gas Corp.
Niagara Mohawk Power Corp.
Pennsylvania Electric Co.
Philadelphia Electric Co.
Potomac Electric Power Co.
Public Service Electric & Gas Co.

Rochester Gas & Electric Corp.
Southern Services, Inc.
Toledo Edison Co.
Wisconsin Electric Power Co.
Wisconsin Power & Light Co.

19. Atomic Power Engineering Group:
    Central Illinois Public Service Co.
    Central Louisiana Electric Co., Inc.
    Central Power & Light Co.
    Interstate Power Co.
    Iowa-Illinois Gas & Electric Co.
    Kentucky Utilities Co.
    Lake Superior District Power Co.
    Northern Indiana Public Service Co.
    Public Service Co. of Indiana, Inc.
    Public Service Co. of Oklahoma.
    Southwestern Electric Power Co.
    West Texas Utilities Co.
20. East Central Nuclear Group (see item 11)
21. Nuclear Power Group (see item 4)
22. Rocky Mountain-Pacific Nuclear Research Group:
    Arizona Public Service Co.
    California Electric Power Co.
    Pacific Power & Light Co.
    Portland General Electric Co.
    Public Service Co. of Colorado.
    Public Service Co. of New Mexico.
    Utah Power & Light Co.
    Washington Water Power Co.
23. San Diego Gas & Electric Co. (participating in same project as Rocky Mountain-Pacific Nuclear Research Group)
24. Southwest Atomic Energy Associates:
    Arkansas Power & Light Co.
    Arkansas-Missouri Power Co.
    Central Louisiana Electric Co., Inc.
    Empire District Electric Co.
    Gulf States Utilities Co.
    Kansas Gas & Electric Co.
    Kansas Power & Light Co.
    Louisiana Power & Light Co.
    Mississippi Power & Light Co.
    Missouri Public Service Co.
    New Orleans Public Service, Inc.
    Oklahoma Gas & Electric Co.
    Public Service Co. of Oklahoma.
    Southwestern Electric Power Co.
    Western Light & Telephone Co., Inc.
25. Texas Atomic Energy Research Foundation:
    Central Power & Light Co.
    Community Public Service Co.
    Dallas Power & Light Co.
    El Paso Electric Co.
    Gulf States Utilities Co.
    Houston Lighting & Power Co.
    Southwestern Electric Power Co.
    Southwestern Public Service Co.
    Texas Electric Service Co.
    Texas Power & Light Co.
    West Texas Utilities Co.
26. Empire State Utilities Power Resources Associates:
    Central Hudson Gas & Electric Corp.
    Consolidated Edison Co. of New York.
    Long Island Lighting Co.
    New York State Electric & Gas Corp.
    Niagara Mohawk Power Corp.
    Orange & Rockland Utilities, Inc.
    Rochester Gas & Electric Corp.

APPENDIX II

Plants in operation

Name of participating utility company and plant	Type of reactor	Electrical capacity of plant—kilowatt (electrical)	Owner of reactor	Operator of reactor	Estimated cost to utility organization	In operation
(1) Duquesne Light Co (Shippingport).	Pressurized water	[1] 60,000	Atomic Energy Commission.	Duquesne Light Co.	[2] $25,197,000	December 1957.
(2) Pacific Gas & Electric Co. (Vallecitos).	Boiling water-prototype for Dresden unit.	5,000	General Electric Co	General Electric Co	[3] 572,000	October 1957.
(3) Southern California Edison Co. (Santa Susana).	Sodium graphite	7,500	Atomic Energy Commission.	Atomics International	[4] 1,697,000	July 1957.

[1] Initial net capacity, ultimate of 100,000 kilowatts gross expected.
[2] Includes $20,200,000 for the conventional portion of the plant and the site, and $5,000,000 toward cost of reactor.
[3] For turbogenerator portion.

(1) The Shippingport Atomic Power Station, the country's first large-scale nuclear power station, was constructed as part of the Atomic Energy Commission's reactor development program. It is jointly owned by the AEC and Duquesne Light Co. Construction of the station was initiated in September 1954 and completed the latter part of 1957. Criticality was achieved on December 2, 1957, and on December 23, 1957 a full 60,000 kilowatt—the expected initial capacity—was generated.

Extensive invaluable information has been obtained on uranium oxide fuel element performance, core reactivity changes and associated control problems, and the technical problems associated with operation and maintenance of nuclear powerplant systems and equipment, including health physics, radiochemistry, and waste disposal problems.

The plant has demonstrated flexibility and load-change response characteristics in excess of those found in conventional steam generating equipment. Also, the availability of the nuclear reactor compares very favorably with conventional boiler plants. Shippingport has produced cost information in many categories which, with a careful consideration of the dual nature of the station, provides a sound basis for making estimates as to costs which would be incurred in other more advanced nuclear stations.

In addition to its use as a test facility and power producer, Shippingport has been used as a training facility for the supervisors of other atomic power stations yet to be put in operation.

(2) The Vallecitos nuclear reactor plant in California, a joint project of General Electric Co. and Pacific Gas & Electric Co., was started in 1956. It was completed and began feeding electricity into Pacific Gas & Electric Co. lines the latter part of 1957. This 5,000-kilowatt pilot plant for the large-scale Dresden nuclear powerplant is the first entirely investor-financed nuclear power reactor project to be completed in the world. Pacific Gas & Electric Co. furnished the turbo-generator facilities and General Electric Co. the reactor.

(3) The Santa Susana plant (the sodium reactor experiment) is a part of the AEC's reactor development program. It was designed, constructed, and is being operated for the AEC by Atomics International. The Southern California Edison Co. installed and is operating the steam electric plant at an estimated cost to the end of 1959 of $1,697,000, and is purchasing the heat energy developed by the reactor for 35 cents per million B.t.u. under a renewed contract. Since going into service in July of 1957, the steam electric plant has been on the line for a total of 3,322 hours and has generated 15,331,050 kilowatt-hours. In June a maximum steam temperature of 1,000° F. was achieved.

Much has been learned about the operating characteristics of a once-through, liquid metal to water steam generator, as well as about the behavior of sodium with respect to its heat transfer, temperature stratification, and flow properties from the operation of this 7,500-kilowatt plant.

Additional controls have been installed that will cause the reactor to follow system electrical load requirements automatically. These controls will be placed in service when the reactor is returned to service following its refueling operation.

APPENDIX III

Plants under construction, design, or contract

Name of organization and plant [1]	Type of reactor	Capacity of plant (kilowatt electric)	Location	Estimated cost to utility organization	In operation by
(4) Commonwealth Edison Co. Nuclear Power Group, Inc. (Dresden).	Boiling water-dual cycle	180,000	Near Joliet, Ill	$51,000,000	Mid-1960.
(5) Consolidated Edison Co. of New York, Inc. (Indian Point).	Pressurized water-thorium-uranium converter	275,000	Indian Point, N.Y.	100,000,000	1961.
(6) Northern States Power Co.-Central Utilities Atomic Power Associates (Pathfinder).	Boiling water with internal nuclear superheater.	66,000	Sioux Falls, S. Dak	22,800,000	1962.
(7) Pacific Gas & Electric Co. (Humboldt Bay)	Advanced boiling water	[2] 50,000	Eureka, Calif	20,000,000	1962.
(8) PRDC-Detroit Edison Co. (Enrico Fermi)	Fast breeder	100,000	Monroe, Mich	79,600,000	1961.[3]
(9) Yankee Atomic Electric Co. (Yankee)	Pressurized water	134,000	Rowe, Mass	57,000,000	1960.
(10) Carolinas Virginia Nuclear Power Associates (Parr Shoals).	Pressurized water-pressure tube, heavy water moderated.	17,000	Parr, S.C	28,000,000	1962.
(11) East Central Nuclear Group-Florida West Coast Nuclear Group.	Gas cooled, heavy water moderated	50,000	Florida west coast	34,898,000	1963.
(12) Philadelphia Electric Co. High Temperature Reactor Development Association, Inc.	High temperature, helium cooled, graphite moderated.	30,000–40,000	Peach Bottom, Pa	24,500,000	1963.
(13) Saxton Nuclear Experimental Corp	Water type	5,000	Saxton, Pa	8,520,000	1961 (estimate).
(14) Consumers Power Co.	Boiling water, high power density	50,000	Big Rock Point, Mich	30,000,000	1962.

[1] Utility company members of respective groups are shown in app. I.
[2] Guaranteed. 60,000 kilowatts expected.
[3] Construction is expected to be essentially complete by October 1960. Insertion of fuel and low power testing will begin shortly thereafter. About 1 year of low to full power testing is scheduled.

(4) The Dresden nuclear power station is a project of Commonwealth Edison Co. with the cooperation of Nuclear Power Group, Inc. Major construction on the 180,000-kilowatt (electric) dual cycle boiling water reactor, located 50 miles from Chicago, Ill., was started in June 1957. This plant, privately financed, is being built by General Electric Co. for a contract price of $45 million. Bechtel Corp. is General Electric's engineering constructor. In addition, overheads and site costs will be something over $6 million. The contract calls for completion by December 7, 1960. Construction is complete and the fuel loading program, including the necessary testing is in progress. Initial criticality occurred October 15, 1959. The project is expected to be ready for full operation by the middle of 1960.

(5) The 275,000-kilowatt Indian Point nuclear powerplant is being financed and constructed by Consolidated Edison Co. of New York, Inc. As of the end of the year the overall project was about 60 percent complete. The containment sphere and foundations within the sphere are complete and installation of the reactor vessel and other equipment inside the sphere commenced in January. The biological shield has been completed. The turbine room and superheater building are substantially complete and installation of the superheater is in progress.

(6) The Pathfinder project is a joint undertaking or Northern States Power Co. and Central Utilities Atomic Power Associates. In 1957 a contract was signed with the AEC to cover research and development assistance for this project under the third round of the power demonstration reactor program. This contract was modified in 1959 to include an internal nuclear superheater in the Pathfinder reactor. The plant will be located on the Big Sioux River about 5 miles northeast of Sioux Falls, S. Dak. The research and development program reached full pace during 1959 with major efforts in superheater and fuel element design. Preparatory field work was started in 1959. Erection of the containment vessel is scheduled to start during 1960 when the full rate of construction will be reached. The plant is scheduled to be in operation in 1962. Northern States Power Co. will own and operate the 66,000-kilowatt plant. It is expected to cost $3.65 million for research and development work. The AEC will contribute the equivalent of $10.3 million for research, development, and waiver of fuel use charges.

(7) The Pacific Gas & Electric Co. is undertaking the development of a 60,000-kilowatt advanced boiling water reactor at Eureka, Calif. This project, scheduled for criticality on July 1, 1962, is to be financed entirely with investor funds, including research and development. Bechtel Corp. will design and construct the plant on a regular commercial basis. General Electric Co. will supply the nuclear and electrical equipment. The total cost of the project is estimated to be $20 million. Detailed design was started in September 1958 and field construction is scheduled to start in April 1960.

(8) The Enrico Fermi atomic powerplant is sopnsored by the Power Reactor Development Co. and the Detroit Edison Co. Atomic Power Development Associates, Inc., is performing research and development and furnishing the reactor design for the project. Major construction began in August 1956 and is proceeding on schedule toward completion in October 1960. Insertion of fuel and low-power testing will begin shortly thereafter. About one year of low to full power testing is scheduled.

All buildings are essentially complete, and much of the auxiliary equipment is on the site and being installed. Erection of the reactor is essentially complete and extensive nonnuclear testing of reactor components in progress.

Cost of this 100,000-kilowatt plant to the utility organizations concerned is expected to be over $79 million. The AEC is contributing the equivalent of the $4.45 million toward this project, being constructed as part of the AEC first round power demonstration reactor program, in the form of research and development work.

(9) The Yankee Atomic Electric Co. is building a 134,000 kilowatt pressurized water reactor at Rowe, Mass., using stainless steel clad uranium oxide fuel elements. The major buildings and structures at the site have been completed, including the 125-foot vapor container sphere. The turbine generator and other items of major mechanical equipment, such as main coolant pumps and steam generators, are presently being installed. The reactor vessel has been delivered. Fuel elements are currently being received for storage. The plant is expected to be in operation in the latter part of 1960.

The project, being undertaken as part of the power demonstration reactor program, is expected to cost about $50 million. Total requirements to be financed are calculated at $57 million, including cost of the initial core, working capital, and preliminary operating costs. In addition, the Atomic Energy Commission is contributing the equivalent of $5 million in the form of research and development work toward the completion of this project.

(10) The Carolinas Virginia Nuclear Power Associates, Inc., formed in 1956, made a proposal to the AEC in August 1957 under the third round of the power demonstration reactor program for the development and construction of a 17,000-kilowatt heavy water moderated and cooled pressure tube reactor nuclear steam generator. The proposal was accepted as a basis for contractual arrangements by the AEC in May 1958. In January 1959 a contract with the AEC covering the project was executed and a contract with Westinghouse Electric Corp. covering research and development work required for the project was completed in June 1959.

The proposed plant, having a design capacity of 17,000 kilowatt is scheduled for completion in 1962. Construction is scheduled to begin in the early spring of 1960. A site at Parr, S.C., has been selected for its location. The associates under the proposed agreement would pay estimated capital cost of about $22 million. The cost of operating the plant will bring the total CVNPA expenditure to about $28 million. Total estimated cost to the AEC will be about $14.6 million.

(11) A research and development program directed to advancing the gas-cooled heavy water moderated pressure tube type reactor is being conducted jointly by the Atomic Energy Commission, East Central Nuclear Group and the Florida West Coast Nuclear Group. The contract between the parties contemplates, subject to certain technical and economic considerations, that FWCNG will construct and operate a 50,000 killowatt (electric) prototype nuclear powerplant with June 30, 1963, as the target date for critical operation. A site for this plant, approximately 35 miles east of Tampa, Fla., has been selected and an application for a construction permit has been submitted to the AEC. The research and development program has been underway since February 1958 and approximately $1,730,000 has been spent as of December 31, 1959.

(12) In November 1958 a proposal was made in response to an invitation from the AEC by Philadelphia Electric Co. in cooperation with the newly organized nonprofit High Temperature Reactor Development Associates, Inc., to design, construct, and operate a prototype high temperature, helium-cooled, graphite moderated nuclear powerplant. The proposal calls for operation of a 30,000-40,000 kilowatt nuclear plant at Peach Bottom, Pa., on the Philadelphia Electric Co. system in 1963. Construction of the plant is on a fixed-price contract basis for $24.5 million. The proposal provides for the AEC to contribute an additional amount up to a maximum of $14.5 million in aid of research and development. The proposal was authorized by Congress in June 1959 and contracts were subsequently signed with the AEC.

(13) In May of 1959 the General Public Utilities Corp. domestic operating subsidiaries formed the Saxton Nuclear Experimental Corp. to construct and operate a 5,000-kilowatt power reactor for the purpose of conducting a research and development program over approximately a 7½-year period. The program will include 5 years of operation with primary emphasis on lowering nuclear power costs through exploring the possibilities of increasing nuclear fuel use efficiences and economies and lowering future nuclear power capital costs.

The reactor facility will be located at the Saxton station of the Pennsylvania Electric Co. and will be hooked on to one of the station's existing 10 Mw turbine generator units. A construction permit recently was issued to the company. The construction schedule calls for excavation to start early in 1960. The estimated construction time from the date of signing of the contract is 30 months and the estimated date for criticality is December 1, 1961.

(14) In June 1959 Consumers Power Co. announced its intentions to build a 50,000 kilowatt, direct-cycle, high-power density, forced-circulation boiling-water reactor for 1962 operation. It is hoped that capacity can be increased to 75,000 kilowatts within 4½ years of operation by means of intense research and development on reactor core and fuel design. The company is at present carrying on contract negotiations with General Electric Co., Bechtel Corp., and the AEC.

An application for the issuance of a construction permit has been made to the AEC. Ot is hopeful that this permit can be issued in time to allow a construction start in mid-April according to schedule.

APPENDIX IV

Projects in various planning stages

Name of organization	Type of reactor	Capacity of plant (kilowatt-electric)	Location	Estimated cost to utility organization	In operation by
New England Electric System	Not yet selected	200,000-300,000	New England		1966-67.
Pacific Gas & Electric Co	Light water	300,000 or larger	California	$60,000,000 (approximate)	1964-65.
Southern California Edison Co	Water	300,000 (approximate)	do	Not determined	Not fixed.

(15) A large-scale nuclear powerplant has been authorized for construction by the Board of Directors of New England Electric System. The date for completion and the type have not yet been decided, but it is planned to be of the order of 200,000 to 300,000 kilowatts (electric) for operation about 1966 or 1967. Installation of larger conventional units at Salem Harbor and at the proposed Brayton Point plant, the latter with two units scheduled, one each for 1963 and 1964, has deferred somewhat the original timetable for the New England Electric System reactor.

This plant must, of course, take its place in the orderly development of the future power supply program for the system. It is conceived as a production plant, not an experiment or prototype. In view of the proposed completion date, its precise type or design have not been frozen and the system will continue to analyze and take into account continuing developments in reactor operation and design.

(16) Pacific Gas & Electric Co. is studying manufacturers' proposals for a large-scale reactor. Efforts will continue to be given to the project until a satisfactory conclusion is reached. The utility is hopeful that a decision on the matter can be made in the next few months. A powerplant site suitable for a large nuclear powerplant has been acquired.

(17) The Southern California Edison Co. has received two proposals from manufacturers and constructors for the construction of a nuclear powerplant of an approximate capacity of 300,000 kilowatts. Continuous evaluation studies of the proposals have been in progress including a preliminary and informal discussion with the AEC staff. The company hopes that it will be in a position to make a definitive decision leading to an appropriate application to the Commission within 6 months.

APPENDIX V

Estimate of expenditures by electric utility companies for nuclear power development [1]

	1955 and earlier	1956	1957	1958	1959	1960	1961
Expenditures for plants [2]	10, 568, 000	26, 340, 000	34, 777, 000	50, 621, 000	98, 688, 000	127, 600, 000	84, 200, 000
Other expenditures [3]	2, 058, 000	1, 540, 000	2, 648, 000	4, 379, 000	2, 547, 000	4, 700, 000	2, 400, 000
Total by years	12, 626, 000	27, 880, 000	37, 425, 000	55, 000, 000	101, 235, 000	132, 300, 000	86, 600, 000
Cumulative	12, 626, 000	40, 506, 000	77, 931, 000	132, 931, 000	234, 166, 000	366, 466, 000	453, 066, 000

[1] Based on information obtained from the major nuclear power groups and previous surveys made by Edison Electric Institute.

[2] Estimate of expenditures by electric utility organizations for the following plants in operation, under construction, or contract, including accompanying research and development work, but exclusive of operating costs: Santa Susana, Shippingport, Vallecitos, Dresden, Indian Point, Pathfinder, Humboldt Bay, Enrico Fermi, Yankee, Parr Shoals, ECNG–FWCNG project, Peach Bottom, Saxton, Big Rock Point (Consumers Power Co.).

[3] Includes expenditures by individual companies and groups of companies for nuclear power study, research, and development. These figures do not include expenditures associated with any of the projects listed in (2) above. Included in this category are the following groups: Atomic Power Development Associates, Atomic Power Engineering Group, Nuclear Power Group, Pacific Northwest Power Co. Group, Pennsylvania Power & Light Co. project (up to time of cancellation), Pioneer Service & Engineering Group, Rocky Mountain-Pacific Nuclear Research Group, Southwest Atomic Energy Associates, Texas Atomic Energy Research Associates.

APPENDIX VI

Estimate of future nuclear capability by FPC region at time of regional peak (in megawatts)

Region:[1]	*1970*	*1980*
I	3,140	7,990
II	565	5,090
III	460	3,110
IV	242	5,192
V	2,150	8,751
VI	-----	300
VII	-----	1,000
VIII	1,162	7,467

[1] Federal Power Commission classification.

Source: Report to Select Committee on National Water Resources.

MEMBERS OF THE EDISON ELECTRIC INSTITUTE COMMITTEE ON ATOMIC POWER

E. L. Lindseth (chairman), president, the Cleveland Electric Illuminating Co., Cleveland, Ohio.
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J. K. Busby, president, Pennsylvania Power & Light Co., Allentown, Pa.
W. L. Cisler, president, the Detroit Edison Co., Detroit, Mich.
C. B. Delafield, vice president, Consolidated Edison Co. of New York, Inc., New York, N.Y.
E. H. Dixon, president, Middle South Utilities, Inc., New York, N.Y.
P. A. Fleger, chairman of board, Duquesne Light Co., Pittsburgh, Pa.
G. M. Gadsby, chairman of board, Utah Power & Light Co., Salt Lake City, Utah.
R. E. Ginna, chairman of board, Rochester Gas & Electric Corp., Rochester, N.Y.
J.W. McAfee, president, Union Electric Co., St. Louis, Mo.
C. B. McManus, chairman of board, the Southern Co., Inc., Atlanta, Ga.
I. L. Moore, chairman and chief executive officer, New England Electric System, Boston, Mass.
R. G. Rincliffe, president, Philadelphia Electric Co., Philadelphia, Pa.
Philip Sporn, president, American Electric Power Co., Inc., New York, N.Y.
J. B. Thomas, president, Texas Electric Service Co., Fort Worth, Tex.

(Thereupon at 4:55 p.m., Wednesday, February 24, 1960, a recess was taken until Thursday, February 25, 1960, at 2 p.m.)

DEVELOPMENT, GROWTH, AND STATE OF THE ATOMIC ENERGY INDUSTRY

THURSDAY, FEBRUARY 25, 1960

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
Washington, D.C.

The committee met, pursuant to recess, at 2 p.m., in room P–63, the Capitol, Senator Clinton P. Anderson (chairman of the Joint Committee) presiding.

Present: Senators Anderson and Dworshak; Representatives Holifield, Van Zandt, Durham, Price, and Aspinall.

Also present: James T. Ramey, executive director, and George F. Murphy, professional staff member.

Representative HOLIFIELD. The committee will be in order.

The first witness today is Mr. Andrew J. Biemiller.

Mr. Biemiller, you may proceed.

STATEMENT OF ANDREW J. BIEMILLER, DIRECTOR, DEPARTMENT OF LEGISLATION, CONGRESS OF INDUSTRIAL ORGANIZATIONS, CHAIRMAN, AFL–CIO STAFF SUBCOMMITTEE ON ATOMIC ENERGY AND NATURAL RESOURCES

Mr. BIEMILLER. Mr. Chairman, for the record, my name is Andrew J. Biemiller. I am director of the department of legislation, American Federation of Labor and Congress of Industrial Organizations. I am also chairman of the AFL–CIO staff subcommittee on atomic energy and natural resources.

We have a lengthy statement that I would like to file for the record and I have a summary that I would like to present for the committee.

Representative HOLIFIELD. We will be glad to receive the document (p. 435).

Mr. BIEMILLER. I am here to present the views of the AFL–CIO on certain aspects of peaceful atomic development in America during 1959.

The year 1959 has been a serious setback to workers in the field of radiation, health, and safety and very little has been added to the record of peaceful atomic accomplishment.

We have been nevertheless completely convinced by the spokesmen for the Commission and for the Joint Committee thta the atom can be developed as a major new energy force in shaping the future economy of America and the world. We are equally convinced that it has manifold other uses in addition to energy itself making themselves felt in industry—medicine, agriculture, and various fields of scientific re-

search. We believe that atomic development can be made to proceed with full protection to the safety of workers and the general public.

The criticisms labor brings to this occasion can be best understood if they are recognized as our best efforts to add what we can to constructive debate over peaceful atomic development policy.

I request the committee to have included in the record AFL–CIO policy resolution No. 124 on atomic energy, adopted in September 1959 in San Francisco.

Representative HOLIFIELD. It will be received.

(Policy statement referred to by Mr. Biemiller follows:)

POLICY RESOLUTION NO. 124 ADOPTED BY AFL–CIO CONVENTION, SEPTEMBER, 1959, ATOMIC ENERGY

The American labor movement has a most vital and continued interest in the development of the peaceful uses of the atom for mankind. As workers in plants where there is ionizing radiation, as consumers who will benefit from abundant supplies of cheap nuclear power, as taxpayers whose money is invested in huge atomic development, and as citizens who want to see the atom's potential unlocked for the benefit of people throughout the world, the members of the American labor movement are concerned with adequate programs and policies to develop atomic energy.

The AFL–CIO supports programs in the atomic field to:

1. Establish accelerated programs to develop nuclear power in large amounts and at costs competitive with those of power generated by conventional fuels.
2. Expand uses of radioisotopes in industry, medicine, and agriculture.
3. Achieve greater protection to the health and safety of workers and the general public from radiation hazards.
4. Safeguard development of this new industry from being monopolized by a few large corporations.
5. Aid in securing leadership of the United States in developing widespread practical uses of the atom and aiding free world countries in establishing their own atomic program: Therefore, be it

Resolved by the officers and delegates of the Third Convention of the American Federation of Labor and Congress of Industrial Organizations, That we endorse and work to achieve the following programs in the atomic energy field:

1. ATOMIC POWER PROGRAM

America has lost years of precious time by the failure of the Eisenhower administration to carry forward a vigorous atomic power program. Such a program is needed to build the atomic powerplants to equip our country and its electric utility industry with the economic and technical experience which will make the atom a large-scale, low-cost producer of power for an expanding economy and will enable America to shoulder its proper responsibilities of international leadership.

Great Britain, Soviet Russia, other nations and groups of nations are pressing forward toward competitively priced atomic power. The Eisenhower administration's exclusive dependence upon the private utilities has been a major handicap, for they have failed to meet the challenge by reason of inadequate technical and financial resources, economic uncertainties, and lack of financial incentive to pioneer in a new field.

The American Federation of Labor and Congress of Industrial Organizations calls for a full scale national atomic power development program as a most necessary means of achieving from this giant new energy source supplies of low-cost power for America's future needs. We propose:

(a) To strengthen America's threatened position of world leadership in the peaceful application of nuclear energy and of nuclear power in particular.

(b) To strengthen America's national economy and to benefit American consumers by developing low-cost atomic power without further needless delay.

(c) To demonstrate, by means of larger scale Federal reactor programs, that competitively priced power can be produced from nuclear sources under either private or Federal fixed charges of operation from several different feasible reactor types by 1965, assuming base-load operation and minimum charges for plutonium.

To realize these goals, the Atomic Energy Commission must select a few promising reactor designs for large-scale development, then proceed to build and operate them in order to develop the necessary technical and economic knowledge that will allow these designs to be undertaken by the Nation's utility industry.

The Commission must set forth both immediate and long-range power production goals—1965 for the immediate goal, and 1970 and 1975 for the longer range targets. Reactor types must be large scale for greater economy of operation, but also include smaller designs on a lesser scale to aid smaller utilities, whether cooperatively, publicly, or privately owned, and to assist nations abroad with limited financial resources and nuclear technologies.

Surplus power from Federal demonstration reactor programs should be marketed in conformity with the historic Federal power marketing policies and laws.

Existing subsidy programs to private electric utilities for development of reactor power projects should be reexamined in terms of long-range goals and objectives of developing competitively priced atomic power.

2. RADIATION HEALTH AND SAFETY AND WORKMEN'S COMPENSATION

The widespread and rapidly expanding uses of atomic energy for peaceful purposes must proceed hand in hand with, but not at the expense of, the safety of workers and the general public.

Expansion of America's nuclear industry in each year is adding thousands of additional workers to jobs exposed to ionizing radiation which cannot be detected by human sense organs. Any degree of exposure is considered by medical science to be capable of potential damage to human beings.

The relatively safe progress in occupational health and safety thus far has been achieved because control of radiation hazards has been a Federal responsibility. Continuance of this responsibility is crucial, because the number of injuries, illnesses, and deaths from this cause can correspondingly be expected to mount as the atomic industry grows.

There is an increasing effort on the part of the enemies of organized labor to place the responsibility for carrying out radiation health and safety and workmen's compensation programs into the hands of the various States.

We oppose these concerted efforts now being made to dilute and dissipate Federal responsibility by farming it out to the various States. In particular, we oppose legislation recently reported by the Joint Committee on Atomic Energy which would achieve just such a result in the field of radiation health and safety programs.

The record plainly shows that most States do not now have, nor are they likely to have in the foreseeable future, the financial strength to undertake major radiation health and safety programs. Such programs as are now in existence are for the most part differing in standards, as well as failing to provide full-scale protections.

The record plainly shows that most State workmen's compensation programs provide totally inadequate protection to workers for illnesses, injuries, or deaths incurred as a result of overexposure to ionizing radiation.

By its very nature the problem of protecting workers and the public against radiation hazards is a national, not merely a local problem.

Reorganization of Federal responsibility, not its diminution, is required. In addition to the Atomic Energy Commission, various activities in the field of radiation health and safety are scattered among a number of other Federal agencies and departments. The President's recent Executive order and the legislation passed by the Congress fail to provide an adequate radiation health and safety policy for the Federal Government.

We endorse the following programs affecting the health and safety of workers and the public in the field of radiation exposure and workmen's compensation:

(a) There should be created a National Committee on Radiation Safety with the Surgeon-General of the U.S. Public Health Service, Department of Health, Education and Welfare, as Chairman. The Committee would operate day to day as part of the Public Health Service. It would be responsible for establishing standards constituting the minimum safe levels of ionizing radiation exposure to human beings in the United States from all sources covering all occupations and for applying them nationwide.

(b) All license applications to the Atomic Energy Commission for private use of nuclear material would require approval by the committee as having

fully met minimum health and safety standards and regulations. Any State radiation health and safety program to be approved by the Commission would have to meet the Committee's minimum health and safety standards, and the State plan of operation would be required to include jurisdiction over X-ray, radium, and particle accelerator exposure.

(c) The National Committee on Radiation Safety would be directed and authorized to conduct continuing studies of the source and degree of both natural and manmade radiation in the United States and submit reports and recommendations annually to the Congress.

(d) We will also seek separate legislation to establish a statutory Labor-Management Advisory Committee to advise the Commission or any new Federal agency in order to aid in developing and carrying out sound programs of particular labor-management concern.

(e) The Congress has seen fit to provide for financial protection to industry and the public in the event of a nuclear accident, but has provided no such protection to workers on the job.

The AFL–CIO will work to achieve legislation establishing a Federal workmen's compensation program which would establish uniform Federal standards for workmen's compensation programs covering all sources of occupational illnesses, injuries, and deaths, including those from radiation overexposure. These should constitute the compulsory minimum standards for workmen's compensation programs in all of the States.

(f) The AFL–CIO has strongly supported the International Atomic Energy Agency ever since it was proposed in 1953 by the President as a major element of his atoms-for-peace program. We once again urge that the Agency be made a more effective instrument to bring about widespread assistance to all nations developing their atomic programs and urge that the United States support it by more positive actions than it has demonstrated to the present time. The United States responsibility is particularly heavy since it was the prime mover in the creation of the International Energy Agency. We are gratified at the ratification early this year of the treaty to provide aid to Euratom, but urge that its provisions be made an effective instrument.

(g) We applaud the 43d session of the ILO International Labor Conference this year in approving conclusions for an international labor convention supplemented by formal recommendations with respect to strong protection of workers against ionizing radiation. Special praise is due to the U.S. Labor delegates and those from other free nations, whose fine work in large part was responsible for this achievement. We are hopeful that the 80 member states of the ILO will ratify the convention after it has been adopted by the ILO Conference in 1960. We strongly believe that this will mean a long forward step has been taken in the direction of a firmly established international set of standards governing the protection of all affected workers against exposure to ionizing radiation.

Mr. BIEMILLER. My oral testimony will comprise brief comments on each of the five major aspects of what the AFL–CIO conceives as the desirable end products of peaceful atomic development in America. Each of labor's major goals is quoted from the preamble to our policy resolution No. 124.

"I. ESTABLISH ACCELERATED PROGRAMS TO DEVELOP NUCLEAR POWER IN LARGE AMOUNTS AND AT COSTS COMPETITIVE WITH THOSE OF POWER GENERATED BY CONVENTIONAL FUELS"

On February 16 the Atomic Energy Commission released its four-part report on "The Status and Potential of Civilian Nuclear Power Reactors and Its Plans for Future Development." Its release has come against a general background of adverse criticism of the Commission's past programs.

The Commission's just published reply is the result of 7 months' work by the Reactor Development Division of the Commission. It consists of more than 300 pages of highly technical material, charts, tables, forecasts, and policy statements and findings.

I think it is only accurate to assume that the 1958–68 reactor development program has been forced to spend the night in the Procrustean bed of the Bureau of the Budget. What has emerged is a modest program which may provide another million kilowatts of installed nuclear capacity by the year 1969, if all goes well.

This would conceivably bring America's total developed atomic capacity to the neighborhood of 2 million kilowatts, which was the goal announced in 1955 to be achieved by 1960.

We fail to see the drastic import of Chairman McCone's words, delivered last November in an address to the Atomic Industrial Forum, reflected in the Commission's 10-year nuclear power program.

The Commission is proposing, with varying degrees of firmness, 11 new starts, none of which are contemplated until 1963 or 1964.

By the most optimistic assumptions, the net installed electrical capacity gain by 1970 would be roughly 1 million kilowatts. This is one-half of the amount enthusiastically predicted in 1955 as in the offing by 1960 (2 million installed kilowatts). In 1970 about 2 million kilowatts of nuclear capacity (the former 1960 goal) would be reached with only half of this total contributed by the 10-year program.

Mr. RAMEY. We had testimony yesterday by a representative from the Edison Electric Institute that they expected 7 million kilowatts by 1970.

Mr. BIEMILLER. I am referring to that later on. I am talking about our analysis of the Commission's document. This is our analysis of that. I am going to refer to that Edison Institute forecast later on.

From this it is apparent that the Commission is not proposing an accelerated program but is merely gearing its reactor development blueprint to the limited objective of attaining nuclear power at costs comparable with fossil fuel power where it now cost 7 mills or more per kilowatt hour. This would then presumably be the foundation upon which another program could be proposed to the Congress to undertake the task of further reduction to levels where power costs might be competitive with conventionally fueled facilities in general.

Abundant low-cost nuclear power as a significant contributor to a threefold to fivefold expected increase in national power demand by 1975–80 will not be and is not proposed by the Commission. Whether or not the Commission will consider the atomic power industry as within shooting distance of competitively priced power in the 1975–80 period will depend on the outcome of the present 10-year program now proposed.

There may well be real seriousness of intent behind the announcement of Chairman McCone, as an addendum to his prepared testimony, that Southern California Edison and Pacific Gas & Electric are negotiating with Westinghouse and General Electric with the purpose in mind of each constructing a 300-megawatt pressurized water reactor costing about $60 million. Such a facility is theoretically capable of producing power at about 8 mills per kilowatt hour, about 1 mill in excess of the prevailing cost of a fossil fuel powerplant of the same capacity in California.

If this can now be accomplished without Government subsidy, it would appear that America has emerged in 1960 with competitive commercial nuclear power in high cost fossil fuel areas. The private

utility industry seems to think so, judging by the recent Edison Electric Institute's estimate of 7.7 million kilowatts of commercial nuclear power capacity by 1970. The Commission, however, is simultaneously telling us that we will not gain this major objective until 1970.

We find the situation as difficult to interpret as the Dead Sea Scrolls. It raises some fundamental questions to which we believe the Joint Committee could well attempt to obtain answers in the interest of a sound nuclear power policy.

1. Can America's private nuclear industry now design and construct economically feasible power stations which could be started this year and produce power on completion which can be integrated with a privately owned electric utility's system at a cost competitive with that utility's fossil fuel generated power?

2. Or is the intermediate goal further off, as the Commission now views it in its 10-year program?

3. Or is the intermediate goal even further away in time than about 1970 as some pessimistic experts indicate?

4. On the basis of each of the three assumptions above, where does that leave the major target—nuclear power competitive to cost with fossil fueled power in general?

Should the answer be "Yes" to the first question we raise, the Commission's role in the protoype and demonstration phases of nuclear power reactor development should be drastically reexamined and confined in general to work on advanced concepts. This goes for its existing subsidy policies and any new proposed subsidy device such as capital grants.

If the answer is "Yes" to the second question, can General Electric and Westinghouse really do what they have indicated with respect to providing utilities in 7 mill or higher fuel areas with nuclear power at about this unit cost of production without asking the Federal Government for some kind of nuclear Brannon plan for the utility industry?

This brings us back to our view that the Commission's 10-year program is inadequate in all major respects.

The Commission's role could hardly be termed a positive one. "Alternatively, prototypes could be built and operated by the Commission," says the introduction to part IV of the program. As to the demonstration stage, there is no mention of a dynamic role by the Commission, except to consider possible assistance on initial plants in various concepts useful for demonstration purposes.

Should the answer be "Yes" to the third question, we ask, then the American public should be given the answer as to whether it is technically impossible to bring abundant low-cost atomic power to the consumers of this Nation or whether a new and aggressive policy is needed to get the job done.

The answer to the fourth and last question we have raised—when, if ever, will we find the atom contributing substantially to the Nation's mushrooming power demands?—will in the largest measure depend on how the previous questions are answered, and what policies and programs are then adopted.

What are labor's suggested alternatives to the Commission's new-start program as proposed?

The AFL–CIO bases its questions on the Commission's existing and proposed programs.

We make these proposals for the consideration of the Joint Committee:

1. Why no new starts until 1963? We urge that the Commission's timetable be drastically speeded up and firmed.

2. It is necessary to provide a new core to expand installed power capacity at Shippingport to 150 megawatts. Money for this project should be immediately appropriated.

3. The power aspect of the Hanford dual-purpose plutonium reactor is a most important immediate undertaking. Its potential 700 megawatts is now wasted heat carried into the Columbia River. Surplus power in excess of the needs of the Hanford works should be taken and marketed by the Bonneville Power Administration to its wholesale customers.

4. We urge adoption of legislation to authorize a large-scale demonstration reactor program to be undertaken by the Commission at Commission facilities along the outlines of the Gore-Holifield bills. Last year the executive council of the AFL–CIO endorsed in principle S. 683 by Senator Gore as a desirable legislative approach.

We believe that only if the Commission itself undertakes to unlock the door to competitively priced nuclear power, by such a program will the hopes for abundant nuclear energy be realized in the reasonably near future.

5. We urge that the Joint Committee establish some kind of impartial basis of reviewing the basic power cost assumptions underlying the Commission's program. Moreover, there should be close scrutiny of the negotiations between the two California utilities and General Electric and Westinghouse. There should be some basis to get to the root of the contradictory view of the pessimists and the optimists.

We should like to see an immediate study along these lines undertaken by the Joint Committee headed by a person or persons capable of making such evaluations, free from any biased viewpoint.

In this connection, computations should be made using both Federal and private fixed charges. The Commission's program derives its power cost estimate solely from private fixed charges.

6. Like water development, atomic energy is a resource which should be developed under policies which recognize its public nature and its potential being fully developed in the public interest. Therefore, the United States should play its appropriate and pioneering part in helping to develop the peaceful uses of nuclear power. We propose that the Joint Committee look to the 1954 act with the aim of enabling Federal resources agencies to participate in atomic power development as a yardstick in the field. A yardstick as badly needed as that provided by Congress over the past half century in the area of hydrodevelopment. This could be accomplished by license from the Commission.

"II. ACHIEVE GREATER PROTECTION TO THE HEALTH AND SAFETY OF WORKERS AND THE GENERAL PUBLIC FROM RADIATION HAZARDS"

A. Radiation health and safety

In September 1959, Public Law 86–373 amended the Atomic Energy Act of 1954. The AFL–CIO has consistently opposed this kind

of legislation. We feel that it can gravely threaten the health and safety of hundreds and thousands of workers in ever-growing numbers engaged in jobs where there is exposure to ionizing radiation.

The AFL–CIO atomic energy policy statement adopted in San Francisco emphasizes that:

> The relatively safe progress in occupational health and safety thus far has been achieved because control of radiation hazards has been a Federal responsibility. Continuance of this responsibility is crucial because the number of injuries, illnesses, and deaths from this cause can correspondingly be expected to mount as the atomic industry grows.

Labor's experience with the governments of the various States in the field of social and economic programs has been and continues to be frustrating. We cannot be expected to harbor any confidence that Public Law 86–373 will bring about adequate occupational radiation health and safety programs enacted and effectively carried by the States without bitter opposition from large business.

Public Law 86–373 enables the various States to take over from the Federal Government regulatory authority in the field of occupational radiation dealing with radioactive materials owned by the Commission and used by a private industry under Commission license. It also establishes a Federal Radiation Council to advise the President and other Federal agencies and the various States on radiation matters.

We do not believe the States can do the job assigned them under the new law. To our best belief and knowledge, no State, with the possible exception of New York and California, has an effective program regulating its internal manmade radiation hazards that are of intrastate or local nature.

State activity in the field of regulating the use of fissionable material derived since passage of the 1946 Atomic Energy Act varies widely.

Nineteen States have enacted no statute or regulation dealing with radiation as such.

Laws requiring registration by users of radioactive material or establishment of study or advisory groups have been passed by eight States.

Some regulations, for the most part dealing with occupational exposure, have been issued through existing State departments, sometimes the public health department, less often the State labor department, are on the statute books of 10 States.

The so-called model act drawn up by the National Committee on Radiation Protection and Measurement has been substantially incorporated into 10 State laws.

The NCRPM legislative recommendations propose establishment of a coordinator, with existing State agencies performing the rule-making functions. Most of the above States have not done much to put their acts into effective application.

Undertaking comprehensive regulations, which vary among one another, are the States of California, Minnesota, New York, Pennsylvania, and Texas.

The record shows that the States have not shown willingness or ability to tackle this new occupational health and safety problem.

Thus, the whole future of strong and effective State regulations over occupational health and safety programs dealing with radiation is questionable, and prospects for uniform and effective control remote.

The problem is further complicated by the lack of adequate trained manpower in the radiation safety field.

During the Joint Committee hearings last year on "Employee Radiation Hazards and Workmen's Compensation, Mr. C. A. Nelson pointed out again that "one of the most serious problems the States have right now is that of obtaining people in the field of radiation control and safety."

Mr. Nelson expressed his disappointment in the response from the States to the Commission's training seminars:

> It is apparent that the States did not have many qualified personnel to participate in this program.

We must work under Public Law 86–373 at present, but we do not think it is workable. Therefore, we are urging the Joint Committee and the Congress to amend it drastically.

Specifically, our proposed amendments call for the following changes in Public Law 86–373:

1. Broadening the representation of the Federal Radiation Council (sec. 274h). It should include on a Cabinet level the Secretary of the Interior, the Postmaster General, the Chairmen of the Federal Power Commission, and the Interstate Commerce Commission and the Civil Aeronautics Board.

In addition, there should be named by the President to the Council representatives of the scientific community and a representative of labor, of management, and of the public at large.

2. In section 274h there should be added language to enable the Federal Radiation Council to work with an adequate staff, which will operate on a day-by-day basis, as part of the Department of Health, Education, and Welfare. The Council should be authorized and directed to determine minimum safe levels of radiation exposure to human beings in the United States and to review under such exposure standards private license applications to use fissionable material belonging to the Commission, as well as proposed State plans to assume broader regulatory authority under Public Law 86–373.

Representative HOLIFIELD. Mr. Biemiller, you are aware of the fact that they have only one person on their staff, this Federal Radiation Council that we set up last year?

Mr. BIEMILLER. Quite so.

Representative HOLIFIELD. It is completely inoperative for all practical purposes. It has never been implemented properly. As far as I know, an effective program has never been set up nor have personnel been assigned to do the job. Your remarks, I think, are quite pertinent. I refer back to your No. 1 paragraph and ask you exactly why you feel these particular pepole should be on the Council, and if you feel that with their other duties they could really give any time or attention to this complicated subject.

Mr. BIEMILLER. It is obvious in the case of certain of the people—for example, the Interstate Commerce Commission and the CAB and the Postmaster General—that there are transportation problems that are involved here that, we think, deserve attention. I presume that

the usual course would be followed of the delegation of authority to a trusted person.

Representative HOLIFIELD. I think that is provided in the act.

Mr. BIEMILLER. That is the normal provision.

Representative HOLIFIELD. An assistant could very well be assigned to those duties.

Mr. BIEMILLER. That is right. In the case of the other two gentlemen, you have some questions that, we think, have been learned. The Secretary of Interior, after all, has great problems that may arise out of the whole saline-water program, and the U.S. Geophysical Survey comes into this situation very clearly, and the Federal Power Commission is going to, we hope, have a good deal to say from a long-run point of view about some of the developments which will take place here.

Representative DURHAM. Why did you leave out the AEC in the recommendations for the Government agencies?

Mr. BIEMILLER. They are on. These are suggested additions to the existing legislation.

This amended section should also provide that any State-proposed radiation health and safety program must show that it is already adequately handling its own internal radiation hazards. The Federal Radiation Council should be authorized and directed to make continued studies of radiation in the United States and submit annual reports and recommendations to the Congress.

We recommend amendment to section 274i of the new law for inclusion of a provision enabling the Atomic Energy Commission to provide matching funds of not less than 50 percent of the estimated administrative costs of any approved State radiation health and safety programs.

It was not until May 6, 1959, that the Commission promulgated proposed amendments to its 1955 occupational radiation exposure standards to cover licensed users of fissionable materials owned by the Commission.

I request to have included in the record the AFL–CIO criticism of the proposed amendments contained in a letter to Chairman McCone from our secretary-treasurer, William F. Schnitzler, on June 30, 1959.

Representative HOLIFIELD. It will be received.

(The letter referred to follows:)

JUNE 30, 1959.

Mr. JOHN A. MCCONE,
Chairman, Atomic Energy Commission, Germantown, Md.

DEAR CHAIRMAN MCCONE: This letter contains the official position of the American Federation of Labor and Congress of Industrial Organizations concerning the Atomic Energy Commission's proposed amendments to Title 10, Chapter 1, Part 20, Code of Federal Regulations: "Standards for Protection Against Radiation." These proposed amendments were promulgated in the Federal Register May 6, 1959.

It is hardly necessary to state the direct and vital interest of the AFL–CIO in the Atomic Energy Commission's proposed amendments. They deal primarily with occupational radiation exposure and set forth revised standards governing the maximum permissible dosage considered to be consistent with the health and safety of workers in jobs which expose them to ionizing radiation.

Already, scores of thousands of workers in unions affiliated with the AFL–CIO work in plants where there is radiation exposure. Their number is rapidly growing now, and will mount even more rapidly as industrial, medical, agricultural, and other peaceful uses of atomic energy become more widespread.

It is, therefore, the earnest concern of the AFL–CIO that every worker be accorded the greatest possible protection on the job from radiation through adoption of the strongest possible standards of safety, enforced with undeviating thoroughness and strengthened as more scientific knowledge is brought to bear on this matter.

The AFL–CIO, therefore, addresses to you the following procedural and substantive comment concerning the Commission's proposed amendments to its occupational radiation exposure regulations. They represent the considered judgment of the AFL–CIO as to how they can be improved to accomplish their aim and provide for workers the best possible protection under existing standards of exposure.

We appreciate the Commission's action in allowing the AFL–CIO and other interested parties additional time to make extended comments and recommendations. We also appreciate the cooperation of Messrs. Rogers, Smith, and Loewenstein in discussing the proposed regulations with members of the AFL–CIO Staff Subcommittee on Atomic Energy and Natural Resources. We hope that this informal interchange of views and information will become a part of the working relationships between the AFL–CIO and the Commission.

I hope that it will be possible for one of our staff representatives to discuss with you, or your representatives, in person, the details of our proposals before the new regulations are placed in effect. It is the strong feeling of the AFL–CIO that the suggested modifications will result in the regulations being more effective to improve the health programs involving our workers and will increase their confidence that their Government, through the Atomic Energy Commission, is doing everything possible to control radiation hazards and make their working conditions as safe as present scientific knowledge is capable of doing.

Sincerely yours,

WM. F. SCHNITZLER,
Secretary-Treasurer, AFL–CIO.

RECOMMENDATIONS FOR CHANGES IN PROPOSED REGULATIONS OF ATOMIC ENERGY COMMITTEE ON OCCUPATIONAL EXPOSURE TO RADIATION

The American Federation of Labor & Congress of Industrial Organizations recommends the following procedural and substantive changes to the Atomic Energy Commission's proposed amendments to Title 10, Chapter 1, Part 20, Code of Federal Regulations: Standards for Protection Against Radiation.

Our first procedural recommendation deals with occupational radiation standards in the proposed regulations.

Written in dry, technical, and prolix style, with many cross-references to and citations of other sections of the rules on radiation safety standards, they are not easy for experts in the field to understand fully at a single reading.

Consider, then, the problem of a worker in the plant who is directly affected by what is in these regulations and how much more difficult it is for him to analyze them as posted on a plant safety bulletin board.

The successful application of safety regulations of any kind depends in great part upon how well they are understood by workers whom the regulations are designed to protect.

This is our recommendation:

That in the future, all Commission health and safety standards regulations dealing with and affecting workers be translated into language simple and easy to understand.

The licensee should be required, as a condition of his license, to post on the plant bulletin boards where workers customarily are notified of matters affecting them the official text of the regulations. Next to it, the licensee should be required, as a condition of his license, to post a simplified text which should inform the worker, by means of a footnote, that this is not the official document but an explanation of the official document, and has been prepared by AEC for the purpose of explaining specifically and clearly what the safety regulations call for; how they operate, how they affect the worker, and what is his responsibility along with that of management in cooperating to carry them out in order to achieve maximum health and safety conditions.

Our second procedural recommendation pertains to recordkeeping required of licensees under the amended safety standards regulations (par. (a) of amended 20.401) showing radiation exposure of all individuals for whom personnel monitoring is required in amended section 20.102.

Without making specific recommendations, the staff subcommittee calls to the Commission's attention the vital necessity of including X-ray exposure history in its regulations governing recordkeeping on radiation exposure of workers by the Commission's licensees and contractors.

This is our recommendation:

That paragraph (a) of section 20.401 be further amended to include AEC Form 20–1: Occupational Radiation History, along with the AEC Forms 20–2, 20–3, and 20–4 in the recond sentence of this paragraph.

That the following sentence be added to the last sentence of paragraph (a), 20.401: "The licensee shall be prepared to and shall provide the workers on request with the necessary information concerning his total occupational radiation exposure history, his current occupational radiation whole body, skin of whole body or skin of extremities history, whichever may be asked for, together with his total accumulated dose as related in the limits specified in paragraph (a) section 20.101."

This language is necessary in order to protect the worker and assure that he will have access to all the information concerning his radiation exposure history, whether the licensee maintains his record on the above-mentioned AEC forms, or records all the information required on the AEC form on his own forms or by means of business machine punchcards.

SUBSTANTIVE RECOMMENDATIONS

The purpose of amending section 20.102 is stated in the Commission's "Statement of Consideration" as being based on the burdensome and expensive problem of determining how much previous dosage has been received by a worker coming into a new job which involves radiation exposure. This, the Commission states, would be caused by difficulty and expense of obtaining prior exposure records and lack of records on ionizing radiation exposure received in previous work outside the Commission's jurisdiction. In such a situation, the proposed regulations provide that paragraph (a) of section 20.101 may be used, which would provide rates for the whole body, gonads and blood-forming organs at one-third of existing AEC standards.

Such an option allowed to a licensee would make it possible that a worker coming on a new job and having been previously exposed to or approaching his permissible limit might not be employed under conditions which would reduce his exposure rate in accordance with specifications of paragraph (a), section 20.101, unless such reductions under this kind of situation were made mandatory and not merely permissible.

We propose:

(1) Amendment to the last sentence of paragraph (c)(1), section 20.102, which would then read: "* * * the licensee shall use the dose shown in such records in lieu of the dose specified in the following table."

(2) Amendment to the last sentence of section 20.102 which would then read: "* * * the excess shall be disregarded, and such individuals in a restricted area shall receive exposure to radiation not to exceed the limits specified in the table contained in section 20.101(a)."

We recommend that the attention of the Commission be called to the fact that the lower permissible radiation exposure levels, as set forth by the table in paragraph (a) of section 20.101, will affect relatively few workers—notably those who come into new jobs from previous ones in which they were exposed to ionizing radiation, and whose previous records are either missing or the licensee elects not to bother with obtaining them from the workers' former employers.

Our proposed amendment, as stated above, would automatically invoke the standards in the table in paragraph (a) of section 20.101, in order to meet this situation.

Yet, most workers in plants operated by AEC licensees and passing from the present standards to the proposed new ones, and with exposure doses within present maximum permissible dosage rates, would find no real improvement in their status by the amendments as proposed by the Commission with respect to occupational radiation exposure.

In other words, it is the Commission's intention to follow the stated purpose of the National Committee on Radiation Protection to bring the maximum permissible dose into accord with the trends of scientific opinion, then it should eliminate the options it proposes to allow licensees in determining the conditions under which the reduced exposure levels should be used.

Under the Commission's proposals new workers who have had no previous exposure to radiation and others who are presently on jobs where exposure is within present established limits would continue under the old standards.

We come to these conclusions:

(1) The new NCRP proposed occupational standards of maximum permissible dosage would be virtually meaningless as applied to workers unless they are uniformly applied to all of them.

(2) Unless management as a whole operates under a set of uniform standards, individual concerns who undertake to govern their operations at a lower rate of radiation exposures to their workers will be penalized in competing with others who elect to take the option of remaining with what amounts to the existing standards.

(3) Since the industry is rapidly expanding, both labor and management should be able to rely on uniform standards. Safety and health of workers are the basic foundations for their adoption, and management should be required to build, operate, or modify equipment and installations to this end.

We recommend:

A new paragraph (e) following (d) of section 20.101, which should read: "(e) As used in this section, provisions of paragraph (b) and (c) shall be effective only until the licensee has so established his operations as to comply with the limits of occupational dosage established in paragraph (a) of this section, by the date these regulations go into effect."

We must strongly recommend that reporting notice to individuals of their degree of exposure to radiation should be given more frequently than on a calendar quarter. The reason for this is to provide workers with a greater feeling of security and for analysis of records by the Commission's licensing and inspection staffs to determine if some plants are pushing the limits or are reducing exposure by improved safety measures.

This would necessitate amending paragraph (c) of section 20.404 to substitute the word "months" for "quarters," and in the last paragraph of section 20.404 the word "month" would be substituted for "quarter" and the figure "42 millirem" would be substituted for "125 millirem."

The prpoosed new paragraph (d) section 20.401 should be further amended. Individual radiation exposure records are of vital importance to every worker, not only until December 31, 1964, or 5 years after the worker's employment has been terminated, but very possibly for many more years to come in many instances.

Should a licensed firm go out of business subsequent to December 31, 1964 or subsequent to 5 years after termination of a worker's employment, it would be impossible to locate his records should they be needed. Moreover, this sort of suggested recordkeeping procedure fails to anticipate the requirements of what is hopefully expected to be a rapidly growing industry where maintenance of radiation exposure records and their preservation in a central place will be come more and more an important administrative tool, as well as affording protection to the worker should the latent effects of his accumulated exposure to radiation crop up in future years.

We recommend:

Changing the wording of paragraph (d) section 20.401 to read: "Records of individual radiation exposure which must be maintained pursuant to the provisions of this subsection shall be permanently preserved." The remainder of the sentence should be stricken.

The following should be added to the last sentence of proposed paragraph (d), section 20.401 to read: "copies of such records shall be maintained permanently by the Atomic Energy Commission's Division of Licensing and Regulations and submitted by each licensee on a semiannual basis. In the event of a licensed operator going out of business or discontinuing use of ionizing radiation obtained from the Commission, a final submission of such records shall be made to the Division of Licensing and Regulations specifying the last date of use of fissionable material with respect to each individual worker's radiation exposure history record."

Mr. BIEMILLER. We believe that we have made considerable progress with the Commission staff in acquainting it with labor's views on the aspects of notification to employees, complaint procedures, maintenance of individual exposure records, regular reporting of the work-

er's exposure history, access by workers to safety procedures of the licensed operator, as well as to worker's own exposure history.

We urge that there be no needless delay in making the amended part 20 regulations effective, once they have cleared the Commission. There has already been too much time lost in putting them into effect.

I might add that I am accompanied by Mr. George Taylor, who is the secretary of our staff subcommittee on atomic energy and natural resources; Mr. McGowan, who is international representative for the Boilermakers' Union, who has done extensive work in this field, and is a valued member of our committee. At the appropriate time you may want to ask them some questions, or they may want to contribute something on the question of the safety standards. They have both been working very closely with the Commission staff on this matter.

Until or unless constructive amendments can be made to Public Law 86–373, our State legislatures will assume great importance in the area of radiation health and safety.

We express the hope that the Commission's criteria upon which the proposed State plans will be judged will, as a basic safeguard to workers, adhere to the uniform radiation exposure standards in the existing part 20 regulations of the Commission and that the word "compatible" in Public Law 86–373 will therefore have some meaning.

B. Workmen's compensation

The approach to workmen's compensation for workers disabled from ionizing radiation must be bold. We pointed out to this committee last year that the ordinary diseases of life, which could be triggered either by protracted or limited amounts of acute exposure, could not be causally related to the job and, therefore, were outside the scope of workmen's compensation. It should, therefore, be presumed that the employee's subsequent affliction by such a disease arose in the course of his employment. Not 1 of the 50 State laws today provides for that presumption. Without it there will be no protection to many, many workers injured by exposure to ionizing radiation.

We ask the Congress to amend the Longshoremen's and Harbor Workers' Compensation Act to provide compensation for disability or death resulting from injuries to employees exposed to radiation in the course of or arising out of their employment.

We ask that the amendments to the Longshoremen's and Harbor Workers' Compensation Act broaden the definition of injury in such instances.

We ask that the claimant's right to compensation be preserved without time limitation in the matter of filing claims.

We ask the Congress to specifically spell out the presumption necessary to protect employees so disabled.

We ask that the administrators of these provisions be authorized and directed to determine the necessity, character, and sufficiency of any medical or rehabilitation aid furnished or to be furnished and they be given the authority to order a change of physician when determined to be either desirable or necessary.

We seek a benefit level both for disability and death substantially higher than other workmen's compensation benefit levels because the disabling diseases which can be induced by exposure to radiation have a higher fatality rate.

I realize that the tone of our testimony has been critical of several aspects of the peaceful atomic program. I hope, however, that the alternative suggestions and proposals will be helpful in the deliberations of this committee.

Representative HOLIFIELD. I think it is well to note, Mr. Biemiller, that the staff of the committee and certain members of your staff have been working together to try to formulate legislative solutions to some of these problems.

Mr. BIEMILLER. I am very pleased to have you state that for the record, and I concur. We have been most grateful for the cooperation we have received. We think we have a bill just about perfected that we will attempt to have introduced so that it can be opened up for public inspection and more public discussion.

I have here simply outlined the basic concepts behind the legislation that is just about finally drafted. I repeat that we appreciate very much the cooperation we have had from the committee staff.

Representative HOLIFIELD. We recognize it is a complicated field, this relation of injury to place and time of employment. It is certainly beyond the scope of our present diagnostic methods. Some evaluation or good judgment method will have to be used for the usual type of cause and effect in conventional diseases.

Mr. BIEMILLER. The third major part of our policy statement adopted by our convention, "Safeguard development of this new industry from being monopolized by a few large corporations."

"III. SAFEGUARD DEVELOPMENT OF THIS NEW INDUSTRY FROM BEING MONOPOLIZED BY A FEW LARGE CORPORATIONS"

We wish to commend the Joint Committee and the Congress for extending the cross licensing provisions of the patents sections of the 1954 act for another 5 years.

We wish also to commend Chairman McCone of the Commission for resisting the pressures of the U.S. Chamber of Commerce and the private nuclear industry to withdraw from a large field of activities which the Commission, through its great national laboratories and facilities, conducts in the national interest in its efforts to broaden the impact and benefits of peaceful atomic development. The efforts of private industry to take over the Commission's national laboratories resembles the efforts made by the Second Hoover Commission to create a climate of opinion to sell TVA's power facilities at 10 cents on the dollar and it could have a disastrous effect on the bargaining rights that our unions have built up over many years in Commission installations.

"IV. EXPAND USES OF RADIOISOTOPES IN INDUSTRY, MEDICINE, AND AGRICULTURE"

We also are hopeful that the long forward strides taken by the isotopes program in 1959 will be even greater this year. Indeed, the isotopes program has been the really substantial contribution to date of the entire peaceful nuclear development program in the United States. We fail to realize the thinking behind the abandonment of the food irradiation program.

"V. AID IN SECURING LEADERSHIP OF THE UNITED STATES IN DEVELOPING PRACTICAL USES OF THE ATOM AND AIDING FREE WORLD COUNTRIES IN ESTABLISHING THEIR OWN ATOMIC PROGRAMS"

The lowering of the sights of the Euratom power program is to a degree understandable by virtue of a changed conventional fuel situation, but we hope that this will not mean relaxing policies which will place atomic development on a large scale into its proper place in providing the Western European Community with competitively priced nuclear power in accordance with a forward looking schedule to conserve conventional fuels.

The United States has not adequately supported the International Atomic Energy Agency. The large number of bilateral treaties to which the United States is a party is turning IAEA into what the chairman of the committee has recently described as a paper shuffling organization, narrowly concerned with safety standards.

The AFL–CIO urges that positive policies and programs be adopted now to realize the promise of the atom in humanity. This year should find us moving forward in a new era of restimulated public debate instead of merely marking time.

Representative DURHAM (presiding). Thank you very much, Mr. Biemiller. Are there any questions?

Senator DWORSHAK. Yes, Mr. Chairman.

Mr. Biemiller, I have enjoyed very much listening to your comprehensive statement. I think it covers most of the aspects of atomic energy development. I am particularly concerned with the concluding paragraph on page 7 in which reference is made to the need in securing leadership of the United States in developing practical uses of the atom and aiding free world countries in establishing their own atomic programs. And you refer to Euratom and its apparent failure and also the malfunction of the International Atomic Energy Agency.

Without reminding you that I was opposed to participation of the United States in these two programs, because in the first place I could not reconcile the subsidizing to the extent of almost a half billion dollars the Euratom program to develop public power in Western Europe. That was on the basis of expediting the development of research and development in the European operation which could be utilized in the development of the art in this country. They have broken down, or at least they have slowed down and retarded materially this program in Europe, and there is great concern whether it will ever be revived. Don't you think that if there was justification for the participation of the United States in that program essentially to get research and development of atomic power that we could very well utilize some of the funds to expedite the development of research and development in this country if there is a recognized need for facilitating this particular development. What is your reaction to that?

Mr. BIEMILLER. Senator, may I first of all point out that for a decade the AFL–CIO and previous to merger its two component parts, have been urging the Congress of the United States to appropriate money and lay plans for more intensive development of the peaceful use of the atom in this country. So far that has not been accomplished. We have renewed our plea again in my statement here today.

Secondly, I do not think it is necessarily a case of either/or. I think both ends can be met. I certainly would agree that if Euratom has slowed down to the extent that it now appears probable and hence would not even be in a position to make use of the projected American funds, I certainly would have no objection to seeing those funds utilized for research and development in the United States.

However, I do want to stress the fact that the American labor movement, working with the free trade unions of Europe, through the International Confederation of Free Trade Unions, has backed very strongly the development not only of Euratom, but of the Common Market and the Steel and Coal Community, because we have felt that all of these very economic developments also carried some important political implications, moving in the direction of keeping Europe in a more prosperous condition and hence keeping our very important NATO allies in the best possible position.

So our plea is basically that we do what we can by utilizing our resources and our influence to get Euratom back on the track and get it moving. But above all, let us have research both in the United States and in Europe, because we need it and need it badly.

Senator DWORSHAK. Yes, but the European countries in Euratom prefer to use conventional fuels and they are not particularly interested in atomic power research and development and the construction of plants. Then certainly we should not force them to proceed with that program and it might be much more advisable for use to expedite this same program at home, because if we need nuclear power to supplement the generation of conventional power, we should not be too much discouraged by this development in Western Europe. We ought to be primarily concerned about what is best for the development of atomic energy in this country. Will you agree with that?

Mr. BIEMILLER. I stated a moment ago that if your premise proves to be correct, then I certainly think that we ought to intensify our efforts in the United States. I hope, Senator, that your statement means that we can look forward to support from you for the type of legislation embodied in the Gore-Holified type of bill because that is what we are going to need if we are going to do this.

Senator DWORSHAK. I certainly did not imply any commitment, but I am aware of the need of expediting development in this country. I have taken that position. It was demonstrated last year when our defense appropriations subcommittee authorized the building of a nuclear powered aircraft carrier and provided $35 million for long lead items. Subsequently, the Navy Department said that because of the rapidly increasing cost of building such a nuclear powered aircraft carrier that they decided that they should use conventional power. That points out what I am trying to emphasize. If we have spent in this country $17 or $18 billions on research and development in reactor plants, and the various segments of this entire program, then it seems rather ironical that we have priced ourselves out of actually using nuclear power for aircraft carriers. I would certainly agree with you that we ought to insure maximum development and use of the facilities which we have developed in this country, overlooking the fact, or minimizing the fact that we should not govern our activities or our policymaking in this respect upon what is being done in Western Europe with or without our help.

Mr. BIEMILLER. I agree.

Senator DWORSHAK. You agree with that?

Mr. BIEMILLER. Yes.

Senator DWORSHAK. One more question, Mr. Biemiller. You referred to the fact that the United States has not adequately supported the International Atomic Energy Agency. I don't know what basis you have for that rather conclusive statement.

Mr. BIEMILLER. I believe, Senator, you will find in my statement for the AFL–CIO a year ago some comments on this matter. I don't see they have improved any. We don't think, for example, that we have done what we could in advancing fuels for the use of the Agency. We just simply have the feeling that most of our efforts have been directed to bilateral treaties rather than trying to work through the International Atomic Energy Agency.

Senator DWORSHAK. On the hearings held in this committee on the International Atomic Energy Agency I pointed out to Chairman Strauss that we had 40 or 50 bilateral agreements, and if we wanted to participate vigorously and actively, we had the opportunity to do it through the mechanism of the bilateral agreements. I think this is merely evidence that this Agency was not set up properly, because we were already doing the job or had an opportunity to cooperate with friendly nations in the development of atomic energy. I don't think you can place the blame on the AEC or the Joint Committee or the United States or any segment of our Government for the alleged failure of the international agency. I think it merely bears out the fact that we are not ready yet for that kind of cooperation in this particular program.

Again I would like to point out, and I am sure you will agree with me, that if there is essential need of doing something with these other countries we are able to proceed under the bilateral treaties.

Mr. BIEMILLER. I think, though, that when we try to ride horses going in different directions, we are bound to get into trouble. We have almost a schizophrenia in this area now. We would like to see moves made toward strengthening our cooperation with the International Atomic Energy Agency.

Senator DWORSHAK. You prefer that to the bilateral treaties?

Mr. BIEMILLER. I think in the long run and for the welfare not only of the United States, but the world as a whole, that there is a greater promise through working through the International Atomic Energy Agency.

Senator DWORSHAK. When you realize that some of the Soviet countries and other nations which heretofore have not been very friendly to us internationally are included in the international agency, probably that is the reason for what you say is the lack of success.

Mr. BIEMILLER. Senator, I am well aware of the problems involved there. I represented the International Confederation of Free Trade Unions at the deliberations in the United Nations which led to the creation of this agency, and I am well aware of those problems. I think you also are well aware of the consistent stand of the AFL–CIO on the whole question of dealing with the Kremlin and its satellites. We are the last people in the world who want to see that situation develop whereby we would be aiding such people. On the other hand, we do think that there are safeguards in the International

Atomic Energy Agency, and it is simply to us a matter of basic foreign policy that if we are going to proceed with trying to develop international agencies, we better try to do it, and not just pay lipservice. This is the thing that bothers us.

Senator DWORSHAK. Mr. Biemiller, don't you concede that probably if this International Agency is not as successful as you think it should be that is largely the result of a lack of cooperation of the other nations and not particularly because the United States is reluctant to proceed?

Mr. BIEMILLER. I am not sure that we have wholeheartedly tried to cooperate with the IAEA.

Representative DURHAM. Would the Senator yield?

Senator DWORSHAK. I am through.

Representative DURHAM. We have had an exchange of personnel.

Mr. BIEMILLER. Of this I am aware, but I don't think we have lived up to all of our commitments to the IAEA.

Chairman ANDERSON (presiding). Thank you, Mr. Biemiller.

Mr. BIEMILLER. Mr. Chairman, may I request that my colleague, whom I introduced a few moments ago, Mr. MacGowan, be allowed to comment further on this question of the safety problems that we see ahead of us?

Chairman ANDERSON. Yes. Will you proceed?

(Mr. Biemiller's statement follows:)

STATEMENT OF ANDREW J. BIEMILLER, DIRECTOR, DEPARTMENT OF LEGISLATION, AMERICAN FEDERATION OF LABOR AND CONGRESS OF INDUSTRIAL ORGANIZATIONS

Organized labor has no less vital interest now in the achievement of a positive forward-looking program to harness the atom for mankind, than in the past. We share the feelings of frustration that are expressed by other groups in their annual assessment of where we stand now and expect to stand in the future. We express the hope that public debate on how to go about developing its potential will again this year become strenuous and lively.

Another year has passed into history, a year which saw very little added to the record of peaceful atomic accomplishment and a serious setback to workers in the field of radiation, health and safety.

Nevertheless, we have been completely convinced by spokesmen for the Commission and for the Joint Committee, that the atom can be developed as a major new energy force in shaping the future economy of America and the world. We are equally convinced that it has manifold other uses in addition to energy itself, which already are quietly and pervasively making themselves felt in industry, medicine, agriculture and various fields of scientific research. We believe that atomic development can be made to proceed with full protection to the safety of workers and the general public.

Therefore, the strictures which labor brings to this occasion, can be best understood if they are recognized as our best efforts to add what we can to constructive debate over what kinds of policies and programs will be in our judgment best adopted to realize the prognostications of the experts and by so doing, add to the economic strength of American and the free world.

I request to have included in the record AFL–CIO policy resolution No. 124, on atomic energy, adopted in September 1959 in San Francisco.

My testimony will comprise brief comments on each of the five major aspects of what the AFL–CIO conceives of as the desirable end products of peaceful atomic development in America. Each of labor's major goals are quoted from the preamble to our policy resolution No. 124.

"1. ESTABLISH ACCELERATED PROGRAMS TO DEVELOP NUCLEAR POWER IN LARGE AMOUNTS AND AT COSTS COMPETITIVE WITH THOSE OF POWER GENERATED BY CONVENTIONAL FUELS"

On February 16, the Atomic Energy Commission released its four part report on "The Status and Potential of Civilian Nuclear Power Reactors, and Its

Plans for Future Development." This report and recommendations for a so-called 10-year nuclear power development plan, has been awaited since it was announced as in the making last year.

Its release has come against a general background of adverse criticism of the Commission's past programs by many responsible experts in the field, to which the voice of organized labor has for several years been added.

The honorable chairman of this committee, in a speech delivered January 15 of this year, contrasted the lagging atomic industry with the advent of the decade of the "Soaring Sixties." He contracted the 2 million kilowatts of nuclear power capacity forecast for 1960 by AEC's then Director, Division of Reactor Development in 1955, with the cold actuality of 1960—Shippingport, built under the 1946 act, and now shut down for core replacement, two small nuclear powerplants in California completed, four other projects delayed, and two additional ones canceled.

Representative Holifield in a January 19 speech, took a similar approach to that of the chairman. He added that "somebody laid an egg" as a result of the 1954 Atomic Energy Act amendments, and that "unless we take more vigorous action to make our predictions come true, I fear we may be forever predicting that atomic power will be here in 10 years."

Former AEC Chairman, David Lilienthal has on two recent occasions told reporters that nuclear power has been oversold by its supporters and the present program "is not to be taken seriously."

Admiral Hyman Rickover, the dynamo behind our successful naval reactor program, is of the opinion that competitively priced nuclear power is still 20 years in the future.

In November of last year, Dr. Chauncey Starr, general manager of Atoms International and vice president, North American Aviation, Inc. told the Atomic Industrial Forum in effect "that the atomic development honeymoon was over * * * time for commercial profit from atomic power keeps moving further away, and the possibilities of striking that moving target are less certain. What then has happened to fade the nuclear rose?" asked Dr. Starr. "Simply answered, our national objectives have shrunk."

The Commission's just published reply to this general criticism is the result of 7 months' work by the Reactor Development Division of the Commission. It consists of more than 300 pages of highly technical material, charts, tables, forecasts, and policy statements and findings.

This material was received by the AFL–CIO on the day these hearings began. We are not blessed with a staff of reactor experts and cannot offer expert comment on the technical data that form the foundation for the Commission's recommendations.

I think it is only accurate to assume that the 1958–68 reactor development program has been forced to spend the night in the Procrustean bed of the Bureau of the Budget. What has emerged is a modest program which may provide another million kilowatts of installed nuclear capacity by the year 1969, if all goes well.

This would conceivably bring America's total development atomic capacity to the neighborhood of 2 million kilowatts, which was the goal announced in 1955 to be achieved by 1960.

Chairman McCone expressed a sense of urgency on his return from the Soviet Union. He told the Atomic Industrial Forum in November 1959, that in order to more than match that nation's accomplishments in the field of peaceful nuclear development, we must find ways and means of consolidating our scientific and technical efforts and directing them on an accelerated basis in pursuit of the early accomplishments of important objectives.

We fail to see the drastic import of the AEC chairman's words reflected in the Commission's 10-year nuclear power program.

The Commission is proposing, with varying degrees of firmness, 11 new starts. Three types are pressurized water, one boiling water, one nuclear superheat, one organic moderated, two sodium, one gas cooled, one heavy water and one homogeneous.

No new construction starts on this program are contemplated until 1963 or 1964. The likeliest new start is the pressurized water reactor. The PWR-Spectral design would be started in the "early 1960's," if it appeared promising; the PWR military reactor would perhaps be undertaken in 1962.

No new work on PWR design is contemplated until after 1963 or 1964, at the earliest, although the Commission indicates possibility of a small 20–30-megawatt plant in 1963 or 1964. It is obvious this conclusion is a major conces-

sion of the Budget Bureau's bookkeeping theory of achieving national policy goals.

Probably in 1963, the Commission will begin construction on the nuclear superheat type, while the Commission program states no more prototypes are needed on the organic moderated water concept since the 50-megawatt plant, authorized last year, will be started in 1960–61.

The sodium fast reactor of 100-megawatts is indicated for a start in maybe 1963 or 1964, but the sodium thermal design is not considered as a strong possibility, at any rate not before 1963 or 1964.

Sometime in the "mid sixties" construction is planned to be initiated on a 100-megawatt gas-cooled reactor. No decision on a large natural uranium heavy water plant will be made until 1966 or 1967, and a final decision on a 50-megawatt homogenous reactor is likewise deferred until the late 1960's.

In the most optimistic assumption—namely, that all of the reactor design concepts comprised in the Commission's program are pursued and become critical by 1970, the net installed electrical capacity gain would be roughly 1 million kilowatts. This is one-half of the amount enthusiastically predicted by the AEC in 1955 as in the offing by 1960 (2 million installed kilowatts). Together, with nuclear plants now in operation, under construction or planned under the present partnership program of the Commission, we might expect by 1970 about 2 million kilowatts of nuclear capacity (the former 1960 goal) with only half of this total contributed by the 10-year program.

If it is only kilowatts that are being pursued, then we can only conclude that the existing program will yield as many as the new Commission approach. From this, it is apparent that the Commission is not proposing an accelerated program, but is merely gearing its reactor development blueprint to the limited objective of attaining nuclear power at costs comparable with those of powerplants served by fossil fuels in areas where power now costs 7 mills or more per kilowatt. This would then presumably be the foundation upon which another program could be proposed to the Congress to undertake the task of reducing the unit kilowatt-hour cost of atomic power to levels where it might be competitive with conventionally fueled facilities in lower cost fuel areas, as well.

The net import of this is that abundant low-cost nuclear power as a significant contributor to a three- to five-fold increase in national power demand by 1975–80 just will not be and is not proposed by the Commission. Whether or not the Commission will consider the atomic power industry within shooting distance in the 1975–80 period will depend on the outcome of the present 10-year program now proposed.

At this point, it would be less than just not to recognize the possibility that there is real seriousness of intent behind the announcement of Chairman McCone as an addendum to his prepared testimony that Southern California Edison and Pacific Gas and Electric are negotiating with Westinghouse and General Electric with the purpose in mind of each constructing a 300-megawatt pressurized water reactor costing about $60 million. Apparently it is planned to integrate their power output into their respective systems. Such a facility is theoretically capable of producing power at about 8 mills per kilowatt-hour, about 1 mill in excess of the prevailing cost of a fossil fuel powerplant of the same capacity in the high cost power area.

Judging by the elaborate advertising in trade journals by General Electric and Westinghouse, what is involved here is a so-called "turnkey" arrangement, whereby the manufacturer will design and construct a large scale nuclear powerplant and hand it over to the utility ready to operate.

If this can be now accomplished without Government subsidy, it would appear that America has emerged in 1960 with competitive commercial nuclear power in high cost fossil fuel areas while the Commission is simultaneously telling us through its 10-year plan that we will not gain this major objective until 1970. The private utility industry seems to think so, judging by the recent Edison Electric Institute's estimate of 7.7 million kilowatts of nuclear power capacity by 1970 submitted to the Senate Select Committee on Water Resources.

We find the situation as difficult to interpret as the Dead Sea Scrolls. It raises some fundamental questions to which we believe the Joint Committee could well attempt to obtain answers in the interest of a sound nuclear power policy:

1. Can America's private nuclear industry now design and construct economically feasible power stations which could be started this year and produce power on completion which can be integrated with a privately owned electric utility's system at a cost competitive with that utility's fossil fuel generated power?

2. Or is the intermediate goal further off, as the Commission now views it in its 10-year program?

3. Or is the intermediate goal even further away in time than about 1970, as some pessimistic experts indicate?

4. On the basis of each of the three assumptions above, where does that leave the major target-nuclear power competitive in cost with fossil fueled power anywhere?

Should the answer be "Yes" to the first question we raise, the Commission's role in the prototype and demonstration phases of nuclear power reactor development should be drastically examined and confined in general to work on advanced concepts. Its existing subsidy policies would certainly be subject to similar excision, for it would certainly appear that the industry had at least come of age and could very well stand unaided on its own two feet. Any new proposed subsidy device, such as capital grants, would be immediately suspect.

If the answer be "Yes" to the second question, then it becomes a matter of conjecture as to whether General Electric and Westinghouse can really do what they have indicated with respect to providing utilities in 7 mill or higher fuel areas with nuclear power at about this unit cost of production, without asking the Federal Government for some kind of nuclear Brannan plan for the utility industry.

This brings us back to our view that the Commission's 10-year program is inadequate; in terms of its stated immediate power cost objective, when this objective should be reached, the time table of new starts and the continued wait and see attitude with respect to hope for private utility participation aided by the usual subsidies.

The Commission's role in the proposed program could hardly be termed a positive one. "Alternatively, prototypes could be built and operated by the Commission," says the introduction to part IV of the program. As to the demonstration stage, there is no mention of a dynamic role by the Commission, except "to consider possible assistance on initial plants in various concepts useful for demonstration purposes."

Should the answer be "Yes" to the third question we ask, then the American public should be given the answer as to whether it is technically impossible to bring abundant low-cost atomic power to the consumers of this Nation, or whether a new and aggressive policy is needed to get the job done.

The answer to the fourth and last question we have raised—when, if ever, will we find the atom contributing substantially to the Nation's mushrooming power demands?—will in the largest measure depend on how the previous questions are answered, and what policies and programs are then adopted.

What are labor's suggested alternatives to the Commission's new-start program as proposed?

The AFL–CIO will base its suggestions on the Commission's existing and proposed programs, which have as often as not been given life by the Joint Committee, in many cases against Commission opposition.

With no reactor technician in our organization, we cannot recommend specified reactor types or sizes and provide a schedule of construction that might be followed. It would hardly be possible to accomplish such a feat in a few days when the Commission's new program culminates from 7 months of work by the Division of Reactor Development in consultation with private industry. Even the 10-year blueprint has been fed by a number of previous studies undertaken by or on behalf of the Commission.

We do, however, make these proposals for the consideration of the Joint Committee:

1. Why no new starts until 1963? We urge that the Commission's timetable be drastically speeded up and firmed.

2. It is necessary to provide a new core to expand installed power capacity at Shippingport to 150 megawatts. Money for this project should be immediately appropriated. Shippingport is uniquely valuable as the only fairly large operating power reactor producing valuable information for the utility industry at large.

3. The power aspect of the Hanford dual-purpose plutonium reactor is a most important immediate undertaking. There is a potential of 700 megawatts there, which is now wasted heat carried into the Columbia River. We hope that the optimistic predictions of economic feasibility by General Electric will be borne out by the present study being undertaken for the Commission by Sargent & Lundy. Surplus power in excess of the needs of the Hanford works

should be taken and marketed by the Bonneville Power Administration to its wholesale customers.

4. We urge adoption in this session of Congress of legislation to authorize a large-scale demonstration reactor program with designs to be undertaken by the Commission at Commission facilities, along the outlines of the Gore-Holifield bills. Last year the executive council of the AFL–CIO endorsed in principle, S. 683 by Senator Gore as a desirable legislative approach. We do not deviate in our often stated conviction that only if the Commission itself undertakes to unlock the door to competitively priced nuclear power by such a broad demonstration program will the hopes for abundant nuclear energy be realized in the reasonably near future.

5. I have already raised several questions concerning where we stand and hope to stand with respect to obtaining competitively priced nuclear power. We, therefore, urge that the Joint Committee establish some kind of impartial basis of reviewing the basic power-cost assumptions underlying the Commission's program. Moreover, there should be close scrutiny of the negotiations between the two California utilities and General Electric and Westinghouse companies. The public now has no way of debating the theoretical power-cost question intelligently.

There is before the public, on the one hand, the pessimism of Lilienthal and Rickover and, on the other hand, the optimism of the Commission, Westinghouse, and General Electric, and a panel of leading reactor experts whose unofficial comments reflected in the January 1960 issue of Nucleonics magazine, are strongly optimistic that nuclear power capable of competing with fossil-fuel power in high-cost power areas is within grasp in the 1960's.

Specifically, we should like to see an immediate study along these lines undertaken by the Joint Committee headed by a person or persons capable of making such evaluations, free from any special viewpoint which might reduce the weight of his findings.

In this connection, computations should be made, using both Federal and private fixed charges. The Commission's program derives its power-cost estimate solely from private fixed charges.

6. Like water development, atomic energy is a resource which should be developed under policies which recognize its public nature and the stake of every American as consumer-taxpayer-citizen in its potential being fully developed in the public interest. Therefore, the United States should play its appropriate and pioneering part in helping to develop the peaceful uses of nuclear power. That is why we propose that the Joint Committee look to the 1954 act with the aim of enabling Federal resources agencies to participate in atomic power development as a yardstick in the field, a yardstick as badly needed as that provided by Congress over the past half century in the area of hydro development. This could be accomplished by license from the Commission.

"II. ACHIEVE GREATER PROTECTION TO THE HEALTH AND SAFETY OF WORKERS AND THE GENERAL PUBLIC FROM RADIATION HAZARDS"

A. Radiation health and safety

The AFL–CIO atomic energy policy statement adopted in San Francisco emphasizes that:

"The relatively safe progress in occupational health and safety thus far has been achieved because control of radiation hazards has been a Federal responsibility. Continuance of this responsibility is crucial because the number of injuries, illnesses, and deaths from this cause can correspondingly be expected to mount as the atomic industry grows."

In September 1959, Public Law 86–373 amended the Atomic Energy Act of 1954. The AFL–CIO has consistently opposed this kind of legislation. We feel that it can gravely threaten the health and safety of hundreds and thousands of workers engaged in ever-growing numbers in jobs where there is exposure to ionizing radiation.

Labor's experience with the governments of the various States in the field of social and economic programs has been and continues to be frustrating. We cannot be expected to harbor any confidence that Public Law 86–373 will bring about adequate occupational radiation health and safety programs enacted and

effectively carried out by them without pitched battles against the same anti-labor forces that have prevented workmen's compensation, unemployment compensation, and other similar programs from giving workers, in general, decent protection.

Public Law 86–373 enables the various States to take over from the Federal Government regulatory authority in the field of occupational radiation dealing with radioactive materials owned by the Commission and used by private industry under Commission license. It also establishes a Federal Radiation Council, chaired by the Secretary of Health, Education, and Welfare, to advise the President, other Federal agencies, and the States on radiation matters.

We do not believe the States can do the job assigned them under the new law. To our best belief and knowledge, no State, except possibly California and New York, has an effective program regulating its internal manmade radiation hazards that are of intrastate or local nature. These include radium, X-ray machines, other X-ray devices, particle accelerators, uranium mining, intrastate shipments and storage of fissionable materials, and local waste-disposal problems.

State activity in the field of regulating the use of fissionable material derived since passage of the 1946 Atomic Energy Act varies widely.

The States of Alabama, Arizona, Idaho, Indiana, Iowa, Kansas, Louisiana, Maryland, Michigan, Mississippi, Missouri, Montana, Nebraska, Nevada, New Mexico, North Carolina, Oklahoma, Vermont, and West Virginia have enacted no statute or regulations dealing with radiation as such.

States which have enacted laws requiring registration by users of radioactive material or establishment of study or advisory groups include Georgia, Illinois, North Dakota, Oregon, South Carolina, South Dakota, Virginia, and Wyoming.

Some regulations, for the most part dealing with occupational exposure, have been issued through existing State departments—sometimes the public health department, less often the State labor department—in Arkansas, Colorado, Delaware, Florida, Kentucky, New Jersey, Ohio, Oregon, Utah, and Wisconsin.

The so-called model act, drawn up by the National Committee on Radiation Protection and Measurement, has been incorporated into the State laws in substantial part by Arkansas, Connecticut, Florida, Maine, Massachusetts, New Hampshire, Ohio, Rhode Island, Tennessee, and Washington.

The NCRPM legislative recommendations propose establishment of a coordinator, with existing State agencies performing the rulemaking functions. Most of the above States have not done much to put their acts into effective application.

Undertaking comprehensive regulations, which vary among one another, are the States of California, Minnesota, New York, Pennsylvania, and Texas.

We submit, therefore, that the States have not shown willingness or ability to tackle this new occupational health and safety problem. We also submit that they have not shown the initiative to regulate radiation, which constitutes an intrastate or local situation which has never been proposed for preemption by the Federal Government.

Thus, the whole future of strong and effective State regulation over occupational health and safety programs dealing with regulation is questionable, and prospects for uniform and effective control remote.

The problem faced by workers in seeking adequate safeguards over radiation exposure on their daily jobs is further complicated by the lack of adequate supplies of trained manpower in the radiation safety field.

In 1957, C. A. Nelson, AEC's Director of Inspection, said that the best way of living with this manpower shortage is by means of a single Federal exposure standard applied nationwide. Inspection and enforcement should be carried out against that standard.

During the Joint Committee hearings last year on "Employee Radiation Hazards and Workmen's Compensation," Mr. Nelson pointed out again that "* * * One of the most serious problems the States have right now is that of obtaining people in the field of radiation control and safety." He said that such a problem requires time and money, but that money was not the complete answer, as it is difficult to go out in the open market and hire qualified technical people.

Mr. Nelson expressed his disappointment in the response from the States to the Commission's training program. "* * * It is apparent that the States did not have many qualified personnel to participate in this program."

In spite of our very grave misgiving concerning the effect of this law on the future job safety of workers exposed to ionizing radiation, we recognize that this law is on the statute books.

We must work with this law at present, both on a Federal and State level, but we do not think, in the long run, it is workable. Therefore, we are urging the Joint Committee to amend it drastically.

Specifically, our proposed amendments call for the following changes in Public Law 86–373:

1. Broadening the representation of the Federal Radiation Council (sec. 274h). It should include on a Cabinet level the Secretary of the Interior and the Postmaster General. The Chairman of the Federal Power Commission and the Interstate Commerce Commission and Civil Aeronautics Board should also be included.

In addition, there should be named by the President to the Council representatives of the scientific community and a representative of labor, of management, and of the public at large.

2. In section 274h, there should be added language to enable the Federal Radiation Council to work with an adequate staff, operating on a day-by-day basis, as a part of the Department of Health, Education, and Welfare. The Council should be authorized and directed to determine minimum safe levels of radiation exposure to human beings in the United States and to review under such exposure standards private license applications to use fissionable material belonging to the Commission, as well as proposed State plans to assume broader regulatory authority.

We propose that this amended section should also provide that approval of any State-proposed radiation health and safety program would be contingent on a showing by the State that it was already adequately handling its own internal radiation hazards. The Federal Radiation Council should be authorized and directed to make continued studies of radiation in the United States and submit annual reports and recommendations to the Congress.

We recommend an amendment to section 274i of the new law for inclusion of a provision enabling the Atomic Energy Commission to provide matching funds of not less than 50 percent of the estimated administrative costs of any approved State radiation health and safety program.

Labor has been striving to work with the staff of the Commission to achieve the fullest possible protections for the worker in the revisions of the Commission's part 20 standards governing occupational exposure to licensed users of fissionable material owned by the Commission.

As the committee will recall, the AEC in 1955 adopted NCRPM exposure standards with some modifications, and made them effective in February 1957. NCRPM amended its 1955 exposure standards also in the first part of 1957. One month after the amended standards emanated from NCRPM, they were adopted by AEC. But it was not until May 6, 1959, that the Commission promulgated proposed amendments to its 1955 exposure standards to cover licensed users of fissionable materials owned by the Commission.

I should like to have included in the record the AFL–CIO criticism of the proposed amendments contained in a letter to Chairman McCone from our Secretary-Treasurer William F. Schnitzler.

Since that time, our Staff Subcommittee on Atomic Energy and Natural Resources has been working closely with the staff of the Commission in attempting to strengthen the proposed amendments to the part 20 regulations in order to achieve better protection to the worker exposed on the job to ionizing radiation. We believe that considerable progress has been made in the aspects of proper notification to employees, complaint procedures, maintenance of individual exposure records, regular reporting of the worker's exposure history, access to safety procedures of the licensed operator as well as to the worker's own exposure history.

We urge that there be no needless delay in making the amended part 20 regulations effective once they have cleared the Commission. There has already been too much time lost in putting them into effect.

Until, or unless, constructive amendments can be made to Public Law 86–373, our State legislatures will assume great importance in the area of radiation health and safety.

We express the hope that the Commission's criteria upon which the proposed State plans will be judged will as a basic safeguard to workers adhere to the uniform radiation exposure standards in the existing part 20 regulations of the Commission and that the word "compatible" in Public Law 86–373 will, therefore, come to have some meaning that will be some what reassuring to our workers.

B. Workmen's Compensation

At the hearings before the Subcommittee on Research and Development of the Joint Committee on Atomic Energy last March, we stated that the approach to workmen's compensation for workers disabled from ionizing radiation must be bold or our accomplishment would fall short of the mark. We pointed out that the ordinary diseases of life which could be triggered either by protracted or limited amounts of acute exposure could not be casually related to the job and therefore were outside the scope of workmen's compensation. We stated that in all cases of ordinary disease which can be caused by exposure to ionizing radiation it should be presumed that the employee's subsequent affliction by such a disease arose in the course of his employment. We regretfully report that not one of the 50 State laws today provide for that presumption, and without it there will be no protection to many, many workers injured by exposure to ionizing radiation.

We ask the Congress to amend the Longshoremen's and Harbor Workers' Compensation Act to provide compensation for disability or death resulting from injuries to employees in employments which expose employees to radioactive properties or substances or to Roentgen rays (X-rays) or exposure to ionizing radiation caused by any process involving the use of or direct contact with radium or radioactive properties or substances or the use of or direct exposure to Roentgen rays (X-rays) or ionizing radiation in the course of or arising out of their employment.

We ask that the amendments to the Longshoremen's and Harbor Workers' Compensation Act broaden the definition of injury in such instances.

We ask the Congress to specifically spell out the presumption necessary to protect employees so disabled.

We ask that the claimant's right to compensation be preserved without time limitation in the matter of filing claims.

We ask that the administrators of these provisions have authority and be directed to determine the necessity, character, and sufficiency of any medical or rehabilitation aid furnished or to be furnished, and the authority to order a change of physician when it is determined to be either desirable or necessary.

We seek a benefit level for disability substantially higher than other workmen's compensation benefit levels because the disabling diseases which can be induced by exposure to radiation are more often than less often fatal.

Again, we urge the Congress to establish a national program to solve adequately a national problem.

I realize that the tone of our testimony has been critical of several aspects of the peaceful atomic program. I hope, however, that the alternative suggestions and proposals will be helpful in the deliberations of this committee.

"III. SAFEGUARD DEVELOPMENT OF THE NEW INDUSTRY FROM BEING MONOPOLIZED BY A FEW LARGE CORPORATIONS"

We wish to commend the Joint Committee and the Congress for extending the cross-licensing provisions of the patents section of the 1954 act for another 5 years.

We wish also to commend Chairman McCone of the Commission for resisting the pressures of the U.S. Chamber of Commerce and the private nuclear industry to withdraw from a large field of activities which the Commission, through its great national laboratories, conducts in the national interest in its efforts to broaden the impact and benefits of peaceful atomic development. The efforts of private industry to take over the Commission's national laboratories resembles the efforts made by the Second Hoover Commission to create a climate of opinion to sell TVA's power facilities at 10 cents on the dollar.

"IV. EXPAND USES OF RADIOISOTOPES IN INDUSTRY, MEDICINE, AND AGRICULTURE"

We also are hopeful that the long forward strides taken by the isotopes program in 1959 will be even greater this year. Indeed, the isotopes program has been the really substantial contribution to date of the entire peaceful nuclear development program in the United States. We fail to realize the thinking behind the abandonment of the food irradiation program.

"V. AID IN SECURING LEADERSHIP OF THE UNITED STATES IN DEVELOPING PRACTICAL USES OF THE ATOM AND AIDING FREE WORLD COUNTRIES IN ESTABLISHING THEIR OWN ATOMIC PROGRAMS

The lowering of the sights of the Euratom power program is to a degree understandable by virtue of a changed conventional fuel situation, but we hope that this will not mean relaxing policies which will place atomic development on a large scale into its proper place in providing the Western European Community with competitively priced nuclear power in accordance with a forward looking schedule to conserve conventional fuels.

We also deplore the failure of the United States to support the International Atomic Energy Agency more adequately. The large number of bilateral treaties to which the United States is a party is turning IAEA into what the chairman of this committee has recently described as a paper shuffling organization, narrowly concerned with safety standards.

We in the AFL-CIO and its affiliated unions have never lost sight of the promise of peaceful nuclear development or its potential in shaping the economy of the future in the interest of our Nation and the free world. We believe that this year should find us moving forward in a new area of restimulated public debate instead of marking time.

STATEMENT OF CHARLES F. MacGOWAN, ON BEHALF OF THE AFL-CIO

Mr. MacGOWAN. My name is Charles F. MacGowan. I am an international representative of the International Brotherhood of Boilermakers, Iron Ship Builders, Blacksmiths, Forgers & Helpers of America. My current assignment has been to the field of nuclear energy, having been assigned there by International President William A. Calvin, who, with our executive council, early recognized the impact of nuclear energy upon our trade. I also serve as AFL-CIO representative to the American Standards Association nuclear standards board and on several subcommittees thereof.

Because of the pressing demands upon the time of the members of this Joint Committee, I will restrict my comments to a very narrow area of the Atomic Energy Act, and address myself to one of the significant points in the recent (September 1959) amendment to the Atomic Energy Act of 1954 (Public Law 86-373). This amended section establishes on a statutory basis the Federal Radiation Council (subsection h), besides dealing with the entry of the various State and local governments into matters requiring the regulation and control of nuclear materials, drawing a line between activities "deemed appropriate" for State regulation, "and other activities where continued AEC regulation is necessary."

The Atomic Energy Act of 1954, as amended in section 274, now requires a Federal Radiation Council which will (1) advise the President on matters "directly or indirectly affecting health" in atomic energy, as well as, (2) advise other Federal agencies with respect to formulating radiation standards in these matters, and (3) promulgate and control the programs under which States may assume some of

the regulatory functions which had been reserved exclusively for the U.S. Government through the Atomic Energy Commission.

These are, indeed, grave and important responsibilities. The gravity and responsibility, and hence the importance of this Council are bound to increase as time goes on. It seems accepted theory that the uses of nuclear energy will grow in importance, and it must be assumed that the duties and responsibilities of the Federal Radiation Council will increase at least in direct proportion to growth in the field.

As it is presently organized, the Federal Radiation Council is comprised primarily of Government officials. The Secretaries of Health, Education, and Welfare, Defense, Commerce, and Labor, and the Chairman of the Atomic Energy Commission or their designees are currently functioning on the Council since they are designated by the act. In addition, also to be available to the Council for consultation are the President of the National Academy of Sciences and the Chairman of the National Committee on Radiation Protection and Measurement, and others. Thus, the Council is largely restricted to Government, and its function, by reason of these appointments, is primarily within Government. Indirectly, however, important nongovernmental functions within the field of atomic energy are affected.

If the postulate that "no man knows a job better than the man who is doing it" is acceptable, it is the opinion of organized labor that the appointment of a representative of labor, and possibly one from industry, to this Council will serve a very useful function by bringing to the Council, firsthand, the problems inherent in jobs which are subject to radiation; and the wishes and apprehensions of the people who are functioning in these positions. It will bring, as well, a pragmatic approach to the needed solutions of these problems. It is our feeling that this point was considered by the Congress when it wrote into the law, after specifying by title the Government officials to be appointed: "and such other members as shall be appointed by the President." This phrase, it seems to us, was the means the Congress had of taking into cognizance the fact that there may very well be other, possibly nongovernmental, persons and organizations to whom the subject of radiation is important.

That there are organizations and persons other than Government agencies who attach to the problem of radiation a considerable amount of importance is evident; and Congress, in its wisdom, thus provided the means for those persons to be appointed to the Council. But as yet, there have been no such appointments made, and the Council remains largely governmental. This despite the fact that Chairman Anderson of this committee pointed out (Congressional Record, Sept. 11, 1959) that he believed it to be of great importance that some qualified representatives of the lay public actively participate on the Council, and that the bill (then S. 2568) permitted the President to add to the Council such persons as he may deem important. Thus, both the legislative history as well as the language of the amendment of the act itself have set up a mechanism by which appointment to the Council of representatives of the lay public may be made.

Possibly the original intent of this Council was that it be constituted a technical committee. The fact is that the appointments made thus far appear to constitute the committee as a policy-advisory committee

as opposed to a technical committee. It seems to us that a committee dedicated to the development of policies and the flow of information concerning radiation may best be served by the addition to the Council of members other than Government.

Acting for not only my own international union in this matter, but the staff committee on atomic energy, AFL–CIO, and the metal trades department, AFL–CIO, I have been in contact on a number of occasions with various offices of the Department of Labor. Since the Secretary of Labor is designated to this Council, we felt that the Department of Labor was our primary point of contact with reference to the Council. However sympathetic the Department might be to our cause in this matter, the fact remains that probably the best solution lies in revising the act to specifically provide that members of labor and industry be appointed to this Council.

Parenthetically, I might add that this Council would then be essentially the statutory committee on atomic energy, the need for which the AFL–CIO has testified repeatedly.

The metal trades department of the AFL–CIO has unanimously urged appropriate action so as to make certain that both labor and industry be accorded the right to direct representation on the Federal Radiation Council.

The full text of this statement is attached hereto, and is as follows:

The metal trades department, AFL–CIO, and its 20 affiliated international unions unanimously urge that appropriate action be taken so as to make certain that both labor and management be accorded the right to direct representation of the Federal Radiation Council as established by Public Law 86–373 amending the Atomic Energy Act of 1954, as amended. The principle of direct labor and management representation on such Council is in full accord with the position enunciated repeatedly by the conventions of the metal trades department and conventions of the AFL–CIO.

Therefore, I respectfully submit for consideration by the Joint Committee on Atomic Energy the proposition that the function of the Federal Radiation Council might be improved by the addition of a representative of labor and a representative of industry, and that section 274 of the Atomic Energy Act be thus revised.

This is the end of my statement, Mr. Chairman.

Chairman ANDERSON. I think I should say to you that it was our feeling at the time when this matter was before the Congress that the naming of people other than the ones who were on originally, might have resulted in rejection of the legislation. I wanted to get something passed. I have the same feeling that you do. I would like to see other representations added. Permission was given for the Council. But we have a little trouble with this ourselves because we asked very politely for a report from it, and were equally politely told we would not get it. So it leaves a little something to be desired as it now stands. We do intend to consider it further and explore it further, and maybe we can get some help in the right direction. Thank you.

Mr. BIEMILLER. Senator, you are aware of the fact that the labor movement is very persistent in pushing demands and this is something we have been discussing with this committee for a decade now. I am hopeful, as you say, that we can make some progress in the direction of getting direct representation of both management and labor on this policymaking group.

Chairman ANDERSON. I assure you that the missionary work does not have to be done with this committee or all the members of this committee, but we will try to do a little missionary work along with you.

Mr. BIEMILLER. Thank you.

Chairman ANDERSON. Thank you both for being here.

Mr. Goodman, did I understand you would be kind enough to wait a little bit, and let Dr. Rose testify?

Mr. GOODMAN. I would be very happy to accede to Congressman Van Zandt's request.

Chairman ANDERSON. Thank you. Mr. Rose.

STATEMENT OF HAROLD J. ROSE, VICE PRESIDENT AND CONSULTANT, BITUMINOUS COAL RESEARCH, INC.

Dr. ROSE. My name is Harold J. Rose, and my residence is Pittsburgh. I am vice president and consultant of Bituminous Coal Research, Inc., which is the national research association for bituminous coal. This is a nonprofit research organization which is supported by a large number of coal producers and sales agencies, coal-carrying railroads, equipment manufacturers and large coal users.

My experience includes 42 years of research and development work on coal and coal products. I appear before this committee as a representative of Bituminous Coal Research, Inc., to speak on potential applications of radioisotopes in the coal industry.

My statement is prepared in the form of a summary which will take about 15 or 16 minutes. If you like I will present it, but I can shorten it if you wish.

Chairman ANDERSON. Please proceed.

Dr. ROSE. General aspects of the coal industry: To give perspective on the potential scale of radioisotope uses by the coal industry, a few general aspects will be mentioned.

Coal is one of the world's leading commodities, whether measured by tonnage produced, dollar value, or industrial importance. Coal provides two-thirds of this country's electric power generated from fuels, and 100 percent of the coke used to make iron and steel. Coal is an important source of process heat, of comfort heat and of chemical products. Coal forms the world's largest reserve of concentrated organic raw materials, with proven reserves measured in trillions of tons.

In the United States, coal is produced commercially in 26 States. Production in the year just ended was 410 million tons of bituminous coal and lignite, plus 20 million tons of anthracite. The whole was valued at more than $2 billion at the mines. Recently, Secretary of Interior Seaton forecast that in 15 years time 775 million tons of coal would be needed yearly, or nearly twice the present rate of production. This agrees with forecasts by others, so that bituminous coal is looked upon as an industry which should expand considerably in the reasonably near future.

The largest single increase of coal, incidentally, is to be expected in connection with the electric utilities.

In this era of continuing inflation, bituminous coal has been remarkably stable in price. Although coal miners have received several wage increases and the supplies used by coal miners have increased considerably in cost during the past decade, the average price of bituminous coal in the United States last year was actually less than it was 12 years ago in 1948. This remarkable record has been made possible by large-scale mechanization and automation.

I mention the foregoing to show that the coal industry will continue to make large investments in new facilities, and that it is receptive to new techniques and equipment as they become available.

Radioisotopes are already in successful use by a few coal producers and coal users for various purposes, but some of these applications have had little or no description to date in the technical literature. Many other uses appear to be feasible if the necessary basic research and engineering research are done to establish the technical possibilities. This will encourage the design and use by industry of commercial equipment utilizing radioisotopes.

AEC SURVEY OF RADIOISOTOPES FOR THE COAL INDUSTRY

In accordance with the policy of the Atomic Energy Commission to encourage the use of radioisotopes in the public interest, the Office of Isotopes Development has contracted with Bituminous Coal Research, Inc., to prepare a survey report on—

> * * * the nature and estimated extent of possible applications of radioisotopes and related technology to the mining, transport, and storage of coal by the coal industry, and to storage, in-plant handling, and use of coal by major consumer groups * * *.

This project consists of a survey only, and does not include laboratory research, engineering development, or field tests. Following are some of the uses which appear to be possible, provided the necessary research is done.

UNDERGROUND MINING

Great advances in coal mining performance are being made through mechanization, including continuous mining machines which cut and load coal directly from the seam. The resulting high production rates cause major problems of automatic operation, continuous transportation away from the face, safety, ventilation, dust control, etc., which radioisotopes can help to solve.

KEEPING CONTINUOUS MINERS IN COALBED

The alloy cutters on continuous miners are quickly damaged if they cut into hard roof or floor strata, furthermore resulting impurities are not wanted in coal. A radioisotope sensing device might be developed to keep the cutting head in coal close to the roof or floor rock but without cutting into it. The gage might operate by sensing density changes by gamma radiation "scatter", since the associated shales, sandstones, etc., have nearly twice the density of coal. Or the device might be of the reflection type to sense the change in chemical or physical properties where the coalbed meets roof or floor strata.

MACHINE MAINTENANCE

Modern coal mining is based on expensive machines operating at very heavy loads under severe conditions. Machine maintenance is therefore a major problem; in fact, a study of the costs of mechanized mining will usually show that the best way to get a substantial reduction of present costs would be to get a higher percentage of operating time out of the equipment used. Radioisotopes have many potential applications in preventive and repair maintenance, the selection of best lubricants, etc.

LOAD-BEARING CAPACITY OF MINE FLOORS

The floor strata of underground coal mines have to bear the weight of hundreds of feet of overburden concentrated on the remaining coal pillars and props. The floor also has to carry very heavy moving equipment. The load-bearing capacity of mine floors containing troublesome clay minerals will vary with the moisture content, and can be checked with radioisotope moisture and density gages. Such gages are already in use by civil engineers in connection with airport foundations and so forth.

VENTILATION

Many coal mines liberate large volumes of methane gas which can form explosive mixtures with air over a considerable percentage range. Therefore large volumes of ventilating air must be distributed to every working place to dilute the methane to 1 percent or less. Radioisotope tracers are being considered for studying mine ventilation problems.

DUST CONTROL

There are limitations on the coal dust content of air breathed by miners. Also coal dust can form explosive mixtures with air. Radioisotopes should be considered for the study of coal dust problems, and to facilitate dust collection.

SIGNAL LIGHTS

Radioisotope energized lights which emit colored light continuously for many years without external power source have possibilities in mines as direction indicators, markers, safety exit signs, etc., which would function independent of the mine lighting circuit. If red radioisotope lights of sufficient intensity can be developed, they could find use as warning lights on moving and stationary equipment.

WATER PROBLEMS

The water seeping or flowing into coal mines must be collected and removed, sometimes at considerable expense. To mine a ton of Pennsylvania anthracite, an average of more than 30 tons of water must be pumped out with a high vertical lift. Radioisotopes can be used to trace the source of water entering mines, leading to the control of inflow in some cases.

I have not mentioned specifically strip mining of coal. Certain of these uses will apply there, and some additional ones. Time does not permit development of that important phase.

Representative VAN ZANDT. Will you take a minute to develop this strip mining activity and the application of the isotope?

Dr. ROSE. Yes. About a fourth of all of the bituminous coal mined in the United States is from open pit mines in which huge shovels take off the overburden to open up the coal which is then taken out usually with a smaller shovel. Certain of the problems are similar. For example, a solid foundation is important and haulage roads for the huge trucks that haul the coal. So the use of radioisotopes to measure the density and load capacity of the floor and haulage ways could be important.

There are other possibilities which I have not touched on here with regard to estimating coal quality at the face by an instrument which is brought up to the coal seam and reads off certain characteristics, which could be applied to strip mining as well as to underground mining.

In the fills—after coal is strip mined, it is customary to restore it to agricultural use—in the making of the fill and compacting of it so it will not erode, the density gages would be useful. Once the coal is mined, it does not matter whether it is strip coal or underground mined coal. All of the following things I mention will apply equally to the two methods of mining.

I might say also that in the anthracite mining which is so important in Pennsylvania, similar conditions apply.

The next subject that I will discuss is coal preparation.

Two-thirds of the coal mined in this country, or about 300 million tons annually, is mechanically cleaned. Continuous close control of washery conditions and of quality of product are important. At coal preparation plants, huge tonnages of coal are crushed, screened into sizes, cleaned, dried, and shipped with or without blending. There are many possible applications of radioisotope techniques for continuous testing, automatic control, maintenance and research.

To date, the chief uses of radioisotopes by the coal industry throughout the world have been in coal preparation. I have references to many publications from various continents on the use of radioisotopes in coal preparation plants. They are already in successful use by a few coal producers and users in the United States for various purposes, such as:

1. Automatic control of the density of heavy media suspensions used in cleaning coal.

2. Automatic control of the most efficient solids content of coal slurries being fed to filters at cleaning plants. If they are not thick enough the efficiency is poor. If they are too thick, the lines may plug up. So it is important to maintain them at the right concentration.

3. Determining the cubic foot weight of coal at various depths and locations in large storage piles, when making stockpile inventories. Electric utility plants may have 2 or 3 months' supply of coal on hand representing tremendous tonnages and heavy investments. They have to periodically take inventories.

4. To warn of stoppage of flow of damp coal fines from overhead bins to boilers of a large powerplant.

5. As a tracer in the hydraulic transportation of coal in pipelines.

6. Also, research investigators have made various uses of radioisotopes as tracers for studying the chemical and physical behavior of coal and coal products in various processes. Information has been obtained on important process reactions which could not have been obtained in any other way.

Such uses can be expected to increase as their advantages become better known and appreciated. As other companies learn of this, they will go to nuclear equipment manufacturers and buy the equipment. We don't have to be too much concerned about that. However, there are many other possible applications where research is needed to establish the possibilities such as:

Controlling the operation of coal cleaning jigs, thickeners, etc., by radiation measurement of bed densities at different levels.

Determining the particle size and settling rates of minus 200 mesh coal slurries. That is an important factor both from the standpoint of recovering fines that are now lost, and also keeping them out of the streams in the interest of clean streams.

Using "tagged" flotation reagents, flocculents, dustproofing and freezeproofing compounds (which are applied to coal in very small amounts) to determine their selectivity, coverage, effectiveness, and ultimate fate.

Continuously weighing and/or analyzing moving coal streams on belts, etc.

Studying coal crushing and screening procedures.

TRANSPORTATION AND HANDLING

More than 400 million tons of coal are produced annually and each ton is usually handled several or many times before ultimate use. Thus there are many opportunities for the use of radioisotopes to improve coal transportation and handling. For example:

1. Checking the condition of belt carcasses.
2. Automatic loading of cars.
3. Continuous weighing of coal in motion. For example, one leading railroad has been working with a nuclear engineering laboratory and they believe they are going to be able to weigh loaded coal cars continuously in a train moving 30 miles an hour, in which every car will be weighed and totaled and printed up as the train moves by, by gamma radiation.
4. Applications in the pipeline transportation of coal.
5. Measuring the amount of coal in bins.

SAMPLING, TESTING AND ANALYSIS

Coal is a natural product that occurs in a wide range of ranks, impurities, and types. Coal is produced commercially from some 8,000 mines, and the analysis of coals shipped from a single mine may vary somewhat with screen size and degree of preparation. Therefore, many large coal producers and users regularly sample and test coal shipments.

For several reasons, reliable coal sampling may be rather difficult and expensive, also there are delays in obtaining laboratory test results. Rapid continuous methods for testing coals are needed, which can be applied to the whole coal stream or to an aliquot portion, in order to obtain immediate test results by the use of radioisotopes. They also have important potentials for saving time and cutting costs in coal laboratory procedures.

COAL USES

About 80 percent of the coal used in this country is burned direct in many types of equipment, for power generation, process heat and comfort heating. Most of the remainder is carbonized in coke ovens and the products used for metallurgical and chemical purposes. Coal utilization processes provide opportunities for many of the above mentioned and additional uses for radioisotope techniques, but time does not permit itemizing such uses here. Many of these, such as handling and analysis apply equally to users but they have some special inplant problems where radioisotopes can be used in a unique way.

Next is irradiation of coal.

Limited studies made during the past several years have shown that coal is quite resistant to neutron and gamma ray bombardment, but small effects have been found. However, research should be done on the possible effects of radiation while coal is being processed, for example, during carbonization and gasification.

Right at the instant that coal is undergoing change from a solid to a gaseous or liquid product, it is presumably more vulnerable to radiation than would be the solid coal at room temperature. So that situation should be looked into.

Representative VAN ZANDT. Doctor, what effect does the radiation have on the gasification? Does it increase the B.t.u.'s?

Dr. ROSE. Not much is known, Mr. Van Zandt. A little preliminary work has been done but it has been on a very small scale. It has a little effect on the amount of hydrogen liberated. The point is that this is one of the many cases where we know very little about it. It is one of the things that we should get information on.

Representative VAN ZANDT. Are you familiar with the program being carried on by the Denver Rio Grande Western Railroad?

Dr. ROSE. I have seen several of their news releases. A couple of months ago I wrote to them for more information. As yet I have not received a reply. I have seen an article which they published.

Representative VAN ZANDT. They are active in this particular field, are they not?

Dr. ROSE. Yes. They have reported some work in which the irradiation of coal resulted in breaking the coal down to micron size which could be disseminated in diesel oil. They have proposed that. Although I have been in touch with them lately explaining that I would be glad to make some mention of this in the report for the AEC, I have not received a reply to that letter as yet.

Now a few comments on other coal research and development uses.

Present and potential uses for radioisotopes in coal research, for example tracer techniques, are too numerous to list here. They have already provided important information on the nature of coal processing reactions, that was obtainable in no other way.

Possibilities include basic research on the principles and reactions involved, the best engineering design of equipment, and the evaluation of performance, for most every phase of coal mining, preparation, handling, use, and the control of air and stream pollution.

ESTIMATING COAL RESERVES

Data on American coal reserves are still far from complete. We know our reserves are tremendous but we have no measurement of a lot of the coal. Coal-bearing formations cover about one-seventh of the area of the United States, and multiple coal beds are typical. For example, the West Virginia Geological Survey has reported a sequence of 62 minable coal beds plus 55 unimportant coal beds, or 117 in all in that State. Since any coal bed may vary locally in thickness and quality, borehole logging is of great importance for assessing coal reserves. You won't find all those coal beds at any one point, but you may, through a single boring, pass through a number.

Core drilling provides detailed information but is too expensive for generalized use. However, tens of thousands of boreholes are being or will be drilled through coal-bearing formations for other purposes, such as petroleum, natural gas, salt and other minerals, deep water wells, etc. Radioisotope logging could provide at little additional cost valuable information on the depth, thickness and approximate quality of the coal beds penetrated.

You might be surprised to learn that in counties in Pennsylvania where coal has been mined continuously commercially for a hundred years, we know little or nothing about the tonnage or quality of that coal that is below that coal now being mined. There are tremendous amounts of coal not included in our official reserves.

Representative VAN ZANDT. Doctor, from time to time we hear the statement being made that we have a sufficient amount of coal in this country to meet our needs for the next thousand years.

Dr. ROSE. Yes.

Representative VAN ZANDT. Have you any accurate figures?

Dr. ROSE. I have made such calculation myself using the official estimate of the U.S. Geological Survey and dividing them by the average annual rate of coal consumption for the past 5 or 10 years. When you do that, you get a figure of from 1,000 to 2,000 years. Predictions in the future depend on how much demand will be made on coal in succeeding years. Our energy demand will continue to increase. However, I am confident as a coal man that we have large reserves that are not yet measured or inferred. When we get the facts, we will find that we have considerably more coal than is now in the official estimates. The same thing has been found abroad. In England they have been making estimates of their coal reserves for over a century. They keep finding more coal as they go deeper. America has more coal than the present official estimates, I am confident. The approach I mentioned will help correct that situation.

Representative VAN ZANDT. What you are saying is that through the employment of the radioisotope we could make a more accurate check as to the amount of coal reserves we have in this country.

Dr. ROSE. Yes. Suppose somebody drills a 5,000-foot hole for natural gas or oil and that is all they are interested in, but by lowering a radioisotope probe at a cost of several cents a foot you can scan the whole area, and you can unquestionably—I don't know that it has been done, but there is no technical reason why you cannot do it—you could locate the coal beds, measure their thickness within a few inches, and presumably measure their quality, that is, their ash content, approximately, when we know a little bit more about such techniques for coal.

ESTIMATED COAL RESERVES

Coal beds could be located and measured in boreholes by probes which measure (*a*) density by gamma radiation scatter, or (*b*) total hydrogen by slowing down fast neutrons, or perhaps (*c*) oxygen by neutron bombardment activation. In each case there would be a large difference in the readings obtained from coal beds and from other strata encountered in boreholes. Besides measuring the location and thickness of coal beds, quality could be evaluated to some extent. The point I want to emphasize is that we have so little information as yet on the response of coal from different deposits and beds to radiations, that a considerable amount of basic research has to be done so that any given equipment manufacturer or borehole logger could make these readings and know what they meant. We have to have factual information on which to base their practical use.

COMMUNIST COAL RESERVES AND RESEARCH

The next couple of paragraphs refer to something that concerns me very much as a citizen, and that is the fact that Soviet Russia now has become the world's largest producer of coal, with the United States in second place. Red China is in third place and gaining rapidly. Some people believe that it will surpass the United States in several years in coal production. Based on recent intensive geological explorations, each of these Communist countries now claims coal reserves which far exceed the present official estimates of U.S. coal reserves. Red China claims coal reserves five times the official estimates of the United States. I don't know how reliable the estimates are, but they are very large. That is one reason for a more realistic study of U.S. coal reserves, since coal is basic to the Nation's prosperity and security.

From the best available information it appears that the Communist countries now have more persons engaged in coal research than the rest of the world combined. Published scientific and technical articles show that they are making very extensive use of radioisotopes, geophysical and electronic devices, and so forth, in their drive to surpass the Western World.

In conclusion, radioisotopes are already in limited but successful use for several purposes in the coal industry. Such applications can be expected to increase as the advantages become better known.

However, most of the numerous possibilities for radioisotopes which I have mentioned are still only ideas or suggestions. Much basic research and engineering research will be required to definitely establish the technical possibilities. This is due to the fact that coal is a natural product which varies greatly in rank, type, and purity in various deposits.

Not only is there a wide variation in the composition of the organic content of various coals, but there is an even greater variation in the amount and nature of the mineral impurities which are present. Some of the minor and trace impurities have a large effect in nuclear reactions.

Therefore, systematic research will be required on the response of various coals to different kinds and intensities of nuclear radiation, in order to develop the basic facts of radiation as applied to coal. If such results are to be obtained within a reasonable time, it appears that most of such research must be sponsored by the Federal Government.

Once the basic facts are available, the manufacturers of nuclear and standard equipment should be expected to design and market radioisotope equipment which offers definite advantages to coal producers and users.

It is believed that the survey report now in preparation for AEC, when completed and released, will stimulate much interest in the subject. If this is promptly followed by laboratory research to explore the technical feasibility of the many possibilities cited, this should greatly reduce the time lag for widespread coal industry acceptance of suitable radioisotope techniques.

I thank you.

Representative VAN ZANDT. Doctor, who is preparing this survey report?

Dr. ROSE. Bituminous Coal Research, and I am the principal investigator on the project.

Representative VAN ZANDT. Have you a target date for its presentation?

Dr. ROSE. Yes, we are expected to deliver what is called a draft copy to the Atomic Energy Commission the end of March. They will review it and then make such suggestions as they may have and return it to us, and then we will have a couple of months to provide the necessary hundreds of copies.

Representative VAN ZANDT. Doctor, on page 8, you say in the second paragraph that it appears that most of such research must be sponsored by the Federal Government. Would you say that the Bureau of Mines as it is established today is adequate to carry on this program, or must it be augmented by the type of organization provided for in a bill already passed the House and now pending before a committee of the Senate?

Dr. ROSE. I have a very high regard for the U.S. Bureau of Mines and their personnel and accomplishments. I know of that in detail. Certainly they could handle phases of that. I think in order to handle this on the scale that is warranted by the facts that this could well be an important part of the program under the new coal research bill.

Representative VAN ZANDT. In other words, the bill will simply agument the Bureau of Mines program?

Dr. ROSE. Yes.

Representative VAN ZANDT. By moving into a greater area of research for the coal industry.

Dr. ROSE. Yes. One of the unique features of the bill is that for the first time it would enable the Secretary of the Interior to contract for work by outside organizations. Until now I believe the Bureau had to spend the funds in its own facilities. That to my mind is one of the interesting features of the new bill.

Representative VAN ZANDT. Doctor, would you take a minute and furnish the committee with some facts as to the increased efficiency developed in the utilization of coal?

Dr. ROSE. That has been striking, of course, since the beginning of the century, when it took about 12 pounds of coal to make a kilowatt-hour and after a few years it got down to 5, and then it stuck around a level of $1\frac{3}{10}$ pounds for quite a few years; that is, around the war years. I see the monthly figures from the Federal Power Commission. At present it is about 0.88 of a pound. That means it takes a third less coal than it took a few years ago to make a kilowatt-hour. At the same time the builders of large power-plant equipment have improved the mechanical efficiency and the economy of their equipment. They are able to operate at higher ratings with the result that the electric utility people have been able to hold the cost of electricity down to a fairly constant level.

The coal industry by keeping the cost of coal down as I mentioned earlier has also made that possible. So in the United States as an average for all plants, old and new, it requires only 0.88 of a pound of average coal to make a kilowatt-hour. That is going to go down somewhat as the older plants go out of operation and the percentage of new equipment is increased.

Also there are a few technical possibilities whereby a few percent of efficiency can be picked up. I can assure you that the electric utility industry is not leaving any of those unconsidered. They are very active and very alert in investigating every possible way to produce electricity at the lowest possible cost.

Representative VAN ZANDT. In the production of coke, what has been your experience in the application of radiation?

Dr. ROSE. I don't think very much is known about the research possibilities. That is one of the things where we need to have more information. A little work has been going on at Pennsylvania State University in the way of academic research, trying to apply radiation at the instant the coal particles are undergoing transformation. Much work remains to be done. A year and a half ago the Atomic Energy Commission requested the U.S. Bureau of Mines to make some proposals for the effect of irradiation on coal during processing. The Bureau of Mines did work up several projects which have been acknowledged. I don't think any action has been taken on them yet. The Bureau has made some definite proposals on systematically investigating the effect of irradiation on coal during gasification, during carbonization, and during various other phases of processing. It is impossible to predict their commercial importance, but it is certainly one of the things we need to know.

Representative VAN ZANDT. Thank you.

Chairman ANDERSON. Thank you very much, Doctor.

Mr. Goodman.

STATEMENT OF LEO GOODMAN, ATOMIC ENERGY ADVISER, UAW, SECRETARY, ATOMIC ENERGY TECHNICAL COMMITTEE, INDUSTRIAL UNION DEPARTMENT, AFL–CIO

Mr. GOODMAN. Thank you very much, Senator. I hope we have not seen another illustration of the coal industry filibustering progress in atomic energy.

Chairman ANDERSON. We are glad to find how useful the atomic energy is to the coal industry.

Mr. GOODMAN. Yes, I think it would be helpful to those Members of Congress who come from coal-producing areas if the committee could gather and put into the public records the facts regarding the amount of coal that is in the diffusion process in this country. I think it would be helpful to show that the increase of the atomic energy industry has been one of the largest single consumers of coal, and that those in the coal industry who fear progress in atomic energy will come to realize that they are mistaken.

Representative VAN ZANDT. Mr. Chairman, representing as I do a coal area, might I say to Mr. Goodman that we do not object to research and development in the field of atomic power. We have supported it and will continue to suport it, but when Government-financed atomic power gets in competition with free enterprise, then we object. This is the position of the United Mine Workers, the position of the National Coal Association, and it is the position of us who live in the coalfields.

Mr. GOODMAN. When workers in industry have sought to hamper progress and technological change, they have been accused in the past of using those wooden sabots—where comes the term "saboteur"—in terms of the progress of industrial advance and technological change. I think it is unfortunate if some in the coal industry feel that development of atomic energy interferes with their economic well-being, and therefore they are throwing not wooden sabots, but verbal sabots into the wheels of progress of atomic energy.

I am very glad that we open with this subject, because I address myself directly to the reasons we must have a broader outlook.

Representative VAN ZANDT. Mr. Chairman, may I say this to Mr. Goodman: I appreciate very much your yielding to Dr. Rose so I could be here while he was testifying due to having to attend another meeting already underway. Your testimony will be read by me tonight.

Mr. GOODMAN. I would appreciate an opportunity to discuss it with you after you have had a chance to read it.

Representative VAN ZANDT. The door to my office is always open to you.

Mr. GOODMAN. Thank you.

Mr. Chairman, I appreciate the invitation to appear here today. I am Leo Goodman, atomic energy adviser of the United Automobile Workers and secretary of the atomic energy technical committee of the AFL–CIO.

In the relaxed atmosphere of upstate New York, a group of leaders representing all segments of American society interested in the development of atomic energy met through the beneficence of Averell Harriman, under the auspices of an organization, the American Assembly, founded at Columbia University under President Eisen-

hower's sponsorship. I might say, Mr. Chairman, that I use this opening sentence to reveal that my approach that we will be discussing here is totally bipartisan.

This group shared their thinking on U.S. policy in atomic energy development and hammered out a final report. The opening sentences of that final report, in our opinion, prevail today as they did on October 20, 1957, when the report was completed. They said, and I quote:

> The United States has attained a worldwide reputation for preeminence in science and technology. Whether we like it or not, the maintenance of the U.S. position in the image already fashioned is a factor in the present world struggle. In such a situation, the position of the United States is inescapably competitive.
>
> The U.S. policy in atomic power development must, for this and other reasons, be appraised not only in domestic but also in international terms.

Judged in these considerations, we believe that the present program is failing to meet the needs of the United States in the world struggle. Even worse, the atoms for peace program so widely promoted seems to be on the verge of collapse. Forces resulting from inconsistent policies by the United States threaten the very existence of the International Agency for Atomic Energy. Likewise, the need for working with our friends and allies in the Western World, particularly in Europe, is being thwarted by industrial consideration while political policy is being ignored.

The late Gordon Dean, former Chairman of the Commission, said, in June 1955:

> People everywhere want cheap power. The atom gives great promise of supplying it. And the United States has many times in the past 2 years promised assistance in this field but we are not delivering on our promises.

The reason we have not delivered was stated to this committee by Walter Reuther in his separate opinion to you of the Panel on Peaceful Uses of Atomic Energy on January 25, 1956. He said:

> We shall not give leadership to other people if we refuse to exercise it in our own behalf. The fact is that the United States is failing to demonstrate the outstanding leadership in releasing atomic energy for peaceful purposes which it demonstrated in putting the atom to work for war.

Since he submitted that report to you, our atomic program has continued the emphasis which he deplored. The best illustration of that is revealed in a study of budget allocations under the public portion of the Federal budget.

I may break in here to say the reason I am using the phrase public portion of the Federal budget is that I see evidences of a secret budget, segments of which are not known to the public, and therefore which we cannot address ourselves to here.

Nuclear weapons production and the procurement of raw material and the preparation of fissionable material for nuclear weapons and the application of nuclear science for other military uses continues to receive approximately 95 percent of the annual public appropriations for atomic energy.

I do not intend to raise the collateral question here as to the value of the accelerated increase in the nuclear stockpile which increased production efficiency, lowered uranium ore costs, technological change and automation have introduced in the cost factors involved in weapons production. I hope this committee will agree, however, with the implications of the Arden House statement with which I opened,

and support a reconsideration of the present inadequate sums being allocated to peaceful uses of the nuclear sciences.

Stated another way, I hope this committee will continue to strive as it is has in the past, that the nuclear sciences which today consume over 9 percent of all the electrical power produced in the United States will, instead, contribute blocks of electric power to our industrial economy and by our own example here in the United States, set the pattern of peaceful use of this science which may then be copied throughout the free world and thus finally help erase from man's mind the mushroom cloud with which U.S. use of this science is most prominently associated in many parts of the world.

I propose specifically that the successful pressurized water reactor known as the package reactor, be turned from its military application by the production of 1,000 such units using the skills of modern production line technology. A drop in cost would result, I am told by competent engineers, to 30 percent of the fixed price paid for the Fort Belvoir custom-made, I should say handmade, model; and that these 1,000 reactors be offered through the International Atomic Energy Agency, to power hungry areas in the uncommitted areas of the world in a U.S. drive to light the backward areas with nuclear power. Of course, many will say it cannot be done, it would not be economically feasible, but these will be merely the modern version of those who said the farms in the United States could not be electrified. Between 1935 and 1955 in the United States we increased the percentage of farm families served by electricity from a little over 10 percent to well over 90 percent, and the new forms of economic activity that were necessary to achieve the result are today liquid financially, successful, expanding institutions in American life. There is every reason to believe that a similar fate would result from an effort of the United States to use nuclear energy to supply the power needs in the power-deficient areas of the world. But even more important than the economic success, would be the psychological impact in behalf of the free world of such a venture to light the underdeveloped areas of the world.

(Discussion off the record.)

Mr. GOODMAN. I believe we must aid the International Atomic Energy Agency by integrating the bilateral treaties into that Agency wherever possible. I believe we must also aid that Agency by providing uranium fuel at a price differential which will make it economic for the International Agency to act as a means of providing uranium fuel to those countries which would prefer to deal through an international agency rather than the United States. It is clear to us in organized labor, who merely watch the number of workers involved in the diffusion plants and the amount of electric current consumed, that there has been such an increase in efficiency and productivity that there is every justification for a price drop below the present price levels.

I believe that this committee and the industry should look carefully into the reasons why the Commission should reduce the price of uranium fuel and thereby help improve the economics of this whole science. Just this morning a newspaper carried the article, "Uranium Glut Hurts Boom Town." I think that it probably is true that there is an apparent over-abundance of natural uranium but solely because the use of this science is being held back, in my opinion, by artifically high prices set at an earlier period of time before improved technology

and improved techniques made it possible to reduce prices. A price reduction is long overdue.

Representative HOLIFIELD. You are speaking of the natural uranium?

Mr. GOODWIN. Both natural and enriched.

Representative HOLIFIELD. And the fabricating of the fuel rod?

Mr. GOODWIN. Sir, you are over my head now.

Representative HOLIFIELD. I felt that you were addressing your remarks to the cost that the reactor people have to pay for uranium to put in their fuel rods.

Mr. GOODMAN. Yes. Inevitably a reduction in the cost of enriched uranium would reduce the cost of a fuel element.

Representative HOLIFIELD. I am not sure that actual cost figures are accurate enough to arrive at a determination of whether it is high or low. I rather doubt if we have accurate cost data in this field any more than we have it in waste disposal.

Mr. GOODMAN. A recent adversary of ours in the matter relating to the *Detroit Edison* case, Mr. Jimmy Morrison, made a speech recently to the Federal Bar Association, in which he called for putting the public spotlight on the whole process of determining the price. I think there is great merit to his proposal.

Representative HOLIFIELD. I would certainly be in accord with your desire to determine the prices of every step in this industry. I agree with you on that. I would have to express a little skepticism as to whether the price is too high or not. I do believe that when you get into the waste disposal business—I have some very interesting information which is going to be put into the record, I believe which comes from the Isotopes Specialties Co., a division of Nuclear Corp. of America, which has been operating in the waste disposal field out in California. They have been handling waste disposal under contract with the Air Force for between $4.50 and $6.50 a barrel. It is costing them $22 a barrel to package it. They have lost several hundred thousand dollars, I understand, in trying to render a waste disposal service to industry and to the Air Force and other Government sources.

Mr. GOODMAN. I saw some reference to their also having conflict with some local government officials.

Representative HOLIFIELD. I think that was another private waste disposal group in the Los Angeles area and not this particular group. I know the item to which you refer. The reason I brought this up at this time was to indicate that in my opinion industry is not being charged anywhere near the price or the cost of fuel reprocessing or waste disposal. I would be inclined to think that the cost might go the other way if you took every step into consideration. I still believe that industry in place of being overcharged is being undercharged in these areas where the Government is furnishing certain services.

Mr. GOODMAN. If that is so, Congressman, I think it is doubly important that the public spotlight be put on to the real cost so that the facts are known.

Representative HOLIFIELD. I am in complete agreement with you on the principle of finding out the real cost.

Chairman ANDERSON. I am, too, Mr. Goodman. I do think we would have to say, however, that any attempt to fix the cost of uranium starts off with a certain assumption; a whole body of assumptions. You have to estimate how long a gaseous diffusion plant is going to live. When you have fixed the life, then you have probably pretty well determined whether the cost can go up or down. If it is a very long life you get a very attractive price. I appreciate the suggestion you made because I do think it is something that we ought to look into, to find out what factors are being used in determining present prices and to see whether those factors have become more favorable with the passage of years and we might get to where we would want to reduce prices or raise prices.

Mr. Holifield showed me today for the first time this material on waste disposal, and I must say it raises a brandnew question as to how much you are going to have to add to that field. We appreciate your suggestion and we will take a serious look at it.

Mr. GOODMAN. In any event, I would urge the committee to look favorably on the concept of giving a very substantial price differential to the International Atomic Energy Agency as a means of putting life into that agency. We have had the case which we referred to in our earlier testimony of a Japanese purchase through the international agency and while the United States bid a very substantial price, the Canadian Government gave a 100-percent discount, gave the uranium to the international agency as a gift, and that was a most encouraging development in helping the agency in its maintenance of its morale and hope. But the agency is in a sad and sorry way. In talking to my friends, I put it this way: My wife runs a school for crippled children here in town whose capital investment last year by the U.S. Congress equaled the total operating budget of the International Atomic Energy Agency. I think that is a tragic fact.

Representative HOLIFIELD. I think it is fair to say that there is an inherent conflict in the bilateral agreements because they encroach upon the field in which theoretically the International Atomic Energy Agency is supposed to function. This casts in my mind serious doubt as to whether the International Agency will ever justify its existence.

Mr. GOODMAN. One alternative would be to promote what I believe is policy, that those bilaterals be renegotiated under the umbrella of the international agency. I know there are problems in some countries.

Representative HOLIFIELD. The problem is either way, of course.

Mr. GOODMAN. While we use the great potential of our technical and industrial capacity to help the underdeveloped areas and the uncommitted peoples of the world, we must not, we cannot afford to neglect our friends in Western Europe. Also we should cooperate with Latin America in atomic development in that part of the world. It was in Europe that much of the development of the nuclear science occurred. In addition, there is a great striving for joint industrial activities as a basis for future political unity. The success or failure of a particular company's atomic industry plans in the United States should not be permitted to defeat the official U.S. policy decision to help foster development of a United States of Europe.

One factor in the failure of more adequate response to the Euratom proposals was the fact that industrial firms in the United States undercut the benefit of joining the Euratom program by European utilities just at the time when potential offers were being considered. There are many ways to interfere with foreign policy, but I would hope that no U.S. firm anxious for trade on a "company to company" basis with European utilities would go so far as to violate the long unenforced Logan Act, which I understand is still on the books and subject to potential enforcement.

Representative HOLIFIELD. Would you mind going back to the previous paragraph, Mr. Goodman, and the last sentence there. What is the meaning of that sentence? To what do you allude?

Mr. GOODMAN. I allude to this, sir: I understand that the primary offer made to the European utility companies to participate through the Euratom was the guarantee of the life of the fuel elements. Just as the proposals were about to be filed, one of the U.S. companies offered the European utilities that if they would proceed to negotiate directly rather than through the Euratom agency, they would guarantee fuel elements or the life of the fuel elements and all of the requirements of the Euratom treaty could be avoided.

Now, specifically, General Electric made an offer for the first core of the fuel elements to the European firms at the time that they were considering applying to the Euratom agency, and this has the impact of undercutting the desirability of operating through the agency.

Representative HOLIFIELD. It also had the impact of relieving the taxpayers of the United States from a possible liability on the lifetime guarantee of the fuel.

Mr. GOODMAN. Yes, sir; that is correct. But I believe that we went into this with our eyes open, that we were in favor of the Euratom program for the benefit it would bring politically as well as scientifically. I believe that what happened was an indirect way of interfering with that decision which this committee and the Congress made.

Representative DURHAM. What proof do you have?

Mr. GOODMAN. Sir, all the facts I stated are public.

Those companies which desire trade in the atomic field would find a more profitable venture here in the United States if they would join in support of the programs enunciated by the Joint Committee on Atomic Energy rather than looking for business primarily overseas. There are a number of untapped markets here in the United States. Yesterday, I met with the Massachusetts State Commission of Atomic Energy. There, in New England and the Northeastern States, is a wonderful potential market, which even today meets the criteria established the other day here by Chairman McCone, of the AEC, when he said on page 26 of the transcript:

> Capital costs of a 300-mwe. plant of this type, as quoted recently by the manufacturers on a fixed-price basis, when taken in conjunction with fuel guarantees reported to the Commission by utilities and core manufacturers, indicate that the power produced from such a plant initiated now should be competitive over its life in high-fuel-cost areas of the United States where a plant of this size can be used.

New England certainly fits the requirements there. This meets the requirements of section 44 in the law for preference to the high-cost

areas. You recall that Senator Kennedy proposed that New England be given this preference when your bill was before the Congress in 1954. I hope it will be possible for this committee and Representatives in Congress from New England to jointly work out a successful organizational structure to proceed at the earliest possible date with a 300-mw. or larger plant to achieve the neutron economy which a reactor of that size can develop. As I understand it, estimates are that the capital costs of such a size unit will be as little as $213 per installed kilowatt. If we can combine with this improved neutron economy, the advantages of new technology and automated plants, we shall go a long way toward achieving soon the oft-delayed target date for competitive nuclear power. Similar projects to the New England one would be successful in the North-Central States, Florida; smaller units are needed in our island possessions and Alaska.

Chairman ANDERSON. Just so nobody will question you on that $213, that is merely simple division.

Mr. GOODMAN. Yes.

Chairman ANDERSON. The Westinghouse Corp. presented its plan to a group of utilities. I was present when the presentation was made and they said this will give you a little over 300,000 kilowatts and the price tag is $68 million as a turnkey job. So it is down in the neighborhood of $213 per installed kilowatt.

Mr. GOODMAN. Our experience has been that where we proceed with a plant of this size it always can be upgraded and the number of kilowatts increased and the per capita cost per installed kilowatt actually would go down.

Chairman ANDERSON. Our point is that instead of trying to build this in the Los Angeles area, which already has a vast supply of hydroelectric from Boulder Dam, and also has an abundant supply of rather cheap natural gas and a lot of oil, this might be done in the New England States where the costs are relatively high.

Mr. GOODMAN. In behalf of my friends from California, I do not intend to imply that it should not also be done in California. I do believe that the provision in the law for giving preference to high-cost areas ought to finally come into use.

Chairman ANDERSON. You don't have to worry about these California people. They will do theirs, too. They will build a plant there also.

Representative HOLIFIELD. I have been saying that the relative need as evidenced by the increasing population is so much greater in the Golden West than it is in the East that it has to be taken into consideration.

Mr. GOODMAN. Sir, we have something in this statement for California also. I will come to it shortly.

Representative HOLIFIELD. Let us get to that as quickly as possible.

Mr. GOODMAN. The Northwest needs the power potential which will be available from the dual-purpose reactor at Hanford. The power installation should be planned now. We are pleased to see progress for the expansion of output at the Shippingport reactor. This committee is to be commended for having helped bring that reactor, which is one of the best experimental reactors we have in this country, into being. We hope that the new power will be used to produce electricity rather than the rumored waste of a "heat-sink." If the Duquesne sys-

tem cannot use the power, plans should be made to wheel it to systems which can use it. Or have the Government take over the total plant and show how effective Government operation of this expanded unit can be.

Representative HOLIFIELD. You would be in favor, if the Duquesne Co. does not put up the $15 million necessary for generating equipment, of the Government doing that and furnishing the elecricity to Duquesne at the 8 mill price the same as we are doing now?

Mr. GOODMAN. I would be in favor of the Government putting in the generating plant, but then I would make Duquesne bid for that power against any other competitors who might be interested in having it within wheeling distance.

Chairman ANDERSON. I wanted to tell you, Mr. Goodman, if you had sat on this committee as long as we did and had experienced the struggle we had over just a few tiny kilowatts in the Niagara Hudson affair, you would not be looking for other worlds to conquer.

Mr. GOODMAN. I am merely trying to help maintain scientific integrity in this wonderful experimental reactor at Shippingport. I don't think economic considerations of the company should downgrade the wonderful potential that reactor has.

Chairman ANDERSON. You know we put the money in the bill ourselves and supported it and still support it and still want to see it go ahead. I do hope that a way will be found to utilize this and not put it into some waste.

Mr. GOODMAN. There are some problems. I have been asked by the workers to come out and talk with them. I have found very low morale and spirit in view of the fact that there are efforts to downgrade the wonderful potential of that reactor. I think we ought to use it to its fullest.

Representative HOLIFIELD. This committee put $19 million in the authorization bill last year, I believe, for the upgrading of the capacity of that reactor. Admiral Rickover has assured us that it can go from the original 60,000 kilowatts to 150,000 with a new core.

Mr. GOODMAN. Fresh water from atomic power.

Chairman Anderson is to be commended for the real success out of his long efforts to persuade the Saline Water Division of the Department of the Interior and the Atomic Energy Commission to combine their efforts to achieve fresh water from the sea by the use of nuclear energy. Though there are problems regarding the site chosen at San Diego, Calif.—and I am referring here to the signed contract for the construction of a reactor—in only 5 short years we have come from the potential that this reactor might cost from $4 to $5 billion down to a signed contract for the nuclear portion of this program at only $41½ million.

Chairman ANDERSON. I may say that you must, however, just be very lenient on the scientists who originally thought that this would be a very expensive plant. I think that I was partially responsible for asking the group of people to finally put a figure down. There had been a great deal of talk how much it would cost. That plant was a wholly different type of plant from this one. They thought it would run finally $800 million. Obviously it would have to be a Government project because the municipalities out there could hardly finance that. It was solely for the purpose of desalting water and it

was a very large figure. I think if those same scientists were to take a look at the new processes they probably would revise very rapidly downward that estimate of the cost of that big plant they had in mind. But they did their work prior to the publication of the so-called first McKinney report; and in 1955, even though it is only 5 years ago, it was a very big step in the dark when they had to say how much they thought it would cost to build that plant. I am glad that you like what is being done. I naturally am overjoyed that it is being done because the $800 million plan looked just impossible. There is a site selection problem that is rather pressing right now that may cause a little delay in this program.

Mr. GOODMAN. There are many alternative sites and I think we need to get on with that problem.

Chairman ANDERSON. The problem is being worked on and I started to say "handled." I don't want to use the word "handled" because that might imply that it is solved. It is not yet solved.

Mr. GOODMAN. It may well be that the Navy will yet prove that the position taken by the chairman, and Mr. Holifield here, in regard to the reactor at Detroit as endorsed by the unions who are very happy to advise the committee that we now have finally had enough progress in this case so that the very last brief in the courts was filed yesterday, and I would like, for the record, to give the committee a few copies of that last brief.

Chairman ANDERSON. Mr. Goodman, there is a live quorum in the Senate and I have to leave.

Representative HOLIFIELD. Before you leave that saline section of the presentation, if we can ever get to the point where we can desalt water, we will solve one of the greatest problems and a problem that is going to become greater in the next 25 to 100 years for communities who now feel they have plenty of fresh water. It would certainly help solve the tremendous problem for expanding population in arid areas of the world. If we can ever get to the point where these B.t.u.'s can be produced cheap enough in a desalination plant, it would really be something.

Mr. GOODMAN. I bring you glad tidings. I have made a very close study of the technology and we have reached the time when water is technically available using both nuclear energy and electric power and though the costs of water will never come down to the low figure that Los Angeles is now able to get the surplus water from the Colorado River, which I understand they do get for the low price, because it is temporary, of 25 cents an acre-foot, it will be economic.

The other extreme in the world that I have found is the French Government pays $37,000 an acre-foot to supply their installations in the Sahara Desert. But between those two extremes if one gets down to the average 400 largest cities in the United States we are now within range of fresh water from the ocean at the same cost of potable water to the 400 largest cities in the United States.

Representative HOLIFIELD. I will believe this when I see it, and I hope you are right.

Mr. GOODMAN. Thank you.

Though there are problems regarding the site chosen at San Diego, Calif., this issue can be resolved by the substitution of an alternate site, whose choice does not raise the objections which I understand

the U.S. Navy has raised against the selection of Point Loma, near San Diego, Calif. Nor should this effort be confined to a single plant. If we were considering this earlier in the range of an $800 million plant and we are now down to a $4½ million, we should not leave the success of this program to a single project. Here again a successful operating unit will have worldwide interest and repercussions. The program of the Saline Water Division for the desalinization program should be expanded.

SITE SELECTION PROBLEMS

The objections of the Navy Department to the location of the desalinization plant near San Diego raise the more general problem of the need for further action by this committee regarding site selection for the location of nuclear facilities. The 1954 amendments to the McMahon Act changed the procedure of site selection so drastically that serious unsolved problems required new action by this committee. Action by this committee is particularly necessary in view of the responsibility which it assumed when the indemnity statute was enacted.

Last year the Commission published in the Federal Register a notice of proposed rulemaking, dated May 23, 1959. This proposal was in response to requests and discussions before this committee regarding the need for criteria of site selection. The proposal was weak—in our opinion, too weak. But industry organized an allout attack upon even this weak proposal. Now the AEC has come before you with a new proposal. The AEC's proposal was so thoroughly analyzed by the members of this committee that I will make no effort to repeat that analysis. I would, however, like to point out to the committee the basic fallacy in the Commission's approach to this whole problem. You will recall that in response to the Joint Committee's request the Commission filed a report dated March 22, 1957, entitled "Theoretical Possibilities and Consequences of Major Accidents in Large Nuclear Powerplants."

The conclusions of that report were so frightening that the authors determined to minimize it by a statistical guess which they phrased as follows:

> Estimations so expressed of the probability of reactor accidents having major effects on the public ranged from a chance of 1 in 100,000 to 1 in 1 billion per year for each large reactor.

I suppose in the missile age we could say you would more likely be hit by a nose cone returning back into the atmosphere than you are ever to be hurt by a nuclear reactor.

In contrast to their point of view, I am attaching an appendix A to my statement here tabulating a partial list of accidents involving radiation in the atomic energy industry.

I would like to ask the committee to turn for a moment, if I may, to this appendix. It shows that since 1945 each year we have had an increasing number of accidents releasing substantial quantities of radiation. I have eliminated from this list all of those accidents involving experiments heading toward accidents, all of those accidents involving single individuals and all of those accidents which are military in any nature. I think this list reveals that we have a real

serious problem. If one were to take merely one of the accidents here, November 1952, the NRX accident at Chalk River, Canada, I have included in the next page an analysis from the Canadian Engineering Journal of the human radiation problems that resulted from that reactor accident. I won't bother to read it but it shows the very serious nature of even a single large reactor accident. So I think the fallacy of the Commission's approach that accidents will never happen weakens our efforts to avoid them. I believe our position has been historically proven that when you release and analyze the facts regarding accidents, you can help avoid their repetition.

(App. A follows:)

APPENDIX A.—PARTIAL LIST OF ACCIDENTS INVOLVING RADIATION IN THE ATOMIC ENERGY INDUSTRY

August 1945, criticality accident, Los Alamos, N. Mex.
May 1946, criticality accident, Los Alamos, N. Mex.
June 1949, uranium fire, Los Alamos, N. Mex.
July 1951, Ames Laboratory, Ames. Iowa.
June 1952, criticality accident, Argonne National Laboratory, Lemont, Ill.
August 1952, Ames Laboratory, Ames. Iowa.
November 1952, NRX reactor, Chalk River, Canada.
February 1953, Knolls Laboratory, Schenectady, N.Y.
May 1953, Hanford, Wash.
May 1954, critical assembly building 9213, Oak Ridge, Tenn.
January 1955, Chemical processing plant, Idaho Falls, Idaho.
November 1955, EBR–1, Idaho Falls, Idaho.
November 1955, fire in reactor slug, Hanford, Wash.
January 1956, loss of Co^{60}—Sam Tour, Darby, Conn.
March 1956, carload of uranium scrap derailed and scattered, St. Joe, Idaho.
May 1956, exposure of radiographic source, Fort Belvoir, Va.
June 1956, plutonium exposure, Hanford, Wash.
July 1956, truck accident and fire, Monterey, Tenn.
July 1956, gamma exposures MTR reactor, Idaho Falls, Idaho.
July 1956, thorium explosion, Sylvania Electric Products Co., Bayside, N.Y.
September 1956, thorium explosion and fire, freight car, Detroit, Mich.
October 1956, Lapre No. 1, Los Alamos, N. Mex.
November 1956, Paducah fire, Paducah, Ky.
March 1957, M. W. Kellogg Co., Houston, Tex., releasing of iridium 192.
May 1957, Brookhaven Laboratory, Long Island, N.Y.
June 1957, Western Co., Midland, Tex.
June 1957, plutonium explosion, Rocky Flats, Colo.
June 1957, Russian accident—"It is positively known there was a deadly nuclear mishap."
September 1957, Industrial Welding & Testing Laboratory, Houston, Tex.
September 1957, plutonium fire, Rocky Flats, Colo.
October 1957, Windscale accident, Windscale, England.
February 1958, Tracerlab, Waltham, Mass.
May 1958, Goodyear, Portsmouth, Ohio.
June 1958, uranium fire, Attleboro, Mass.
June 1958, Oak Ridge, Y–12 criticality accident, Oak Ridge, Tenn.
August 1958, Isotopes Specialities, Inc., Burbank, Calif.
November 1958, Loss of Co^{60}-Industrial Welding & Testing Laboratory, Houston, Tex.
November 1958, Release to air-New England Nuclear Corp., Boston, Mass.
December 1958, Los Alamos criticality accident, Los Alamos, N. Mex.
February 1959, Flask of C–14 shattered, Tracer Laboratory, Inc., Waltham, Mass.
April 1959, Hanford plutonium explosion, Hanford, Wash.
November 1959, Building 3019, Plutonium Explosion, Ornl., Oak Ridge, Tenn.

NOVEMBER 1952 NRX REACTOR, CHALK RIVER, CANADA

[From the Engineering Journal, October 1953, the Journal of the Engineering Institute of Canada]

A skilled workman might receive his weekly allowance of radiation within an hour, and thus a much larger crew of workers was needed than would be required in the repair of any other equally complicated industrial machine.

In a few instances a workman could remain within the radiation field for only a very few minutes. Careful planning was required to avoid the necessity of using a prohibitively large number of men. In some instances it was necessary to allow individuals to take a 13 weeks' dosage in a matter of a day or two. This, of course, meant that they were barred from the radioactive area for a period of 13 weeks.

Skilled tradesmen were conserved, wherever possible, by using other men for such operations that did not definitely require trade qualifications. * * * It is interesting to note that, in some operations, use was made of volunteers from various branches of the project who are rarely exposed to radiation. Carpenters, clerks, accountants, janitors, and others donned gas masks and protective clothing, and carried out various tasks under the direction of the supervisory staff of Industrial Operations. * * * The U.S.A.E.C., in cooperation with the U.S. Navy, and particularly the U.S. Naval Radiological Defense Laboratory, were extremely helpful in the early months of dismantling and decontamination. This work provided an opportunity to train personnel in the problems of handling highly contaminated material and equipment.

Mr. GOODMAN. Not all accidents were included. I do not have any evidence that we know of many of the accidents which occur. In this connection I am attaching, as Appendix B, a letter from President Walter P. Reuther to the Federal Radiation Council discussing this aspect of our problem with the Atomic Energy Commission. Accidents do occur. AEC, in our judgment, has not taken adequate steps to meet the radiation hazard problems which we know continue to be serious.

There is still the neglected problem of radon in the mines. The AEC has served notice of continued violation of the uranium mills. We still do not know the full truth regarding the accident in Oak Ridge on November 20 last. I appreciate the committee's efforts to find out the facts in that case, but a more general procedure must be established. I am told in that case, the Joint Committee was advised only by a telephone call.

Mr. RAMEY. I think they later followed up by letter. It is common for them to call us up something occurring and then follow it by letter.

Representative HOLIFIELD. It is to their credit that they phoned us immediately as soon as something happened and then followed up with a letter.

Mr. GOODMAN. I have a copy of the letter they sent you in the last few days. I have not yet had a chance to analyze it. I point out that this accident occurred, as Walter Reuther pointed out in appendix B last November.

APPENDIX B

INDUSTRIAL UNION DEPARTMENT,
Washington, D.C., February 5, 1960.

HON. ARTHUR FLEMMING,
Chairman, Federal Radiation Council,
Secretary of Health, Education, and Welfare, Washington, D.C.

DEAR CHAIRMAN FLEMMING: Recent newspaper disclosures of a serious radiation accident at Oak Ridge, Tenn., impel me to write to you as chairman of the Federal Radiation Council.

The accident in question was originally described as a "small" explosion and as a result was neither reported in the press nor known to workers employed in similar installations in this country. Efforts to seek full information in order to help develop policy to prevent the repetition of this type of accident revealed the fact that neither the Congress nor the agencies affiliated to the Federal Radiation Council had been advised of the seriousness of this accident nor of the steps necessary to prevent its repetition.

As long ago as February, 1957, at a trade union conference of radiation hazards, I urged that all segments of society—government, science, medicine and industry—work together to find the answers to help meet the problems which this new science brings to the workers in industry.

It seems to me that we have relied too long upon the Atomic Energy Commission exclusively for information regarding mistakes or accidents in the plants which it administers. Your Federal Radiation Council provides an opportunity for an unbiased, impartial source of information upon which the public and the workers in the industry can rely. I strongly urge that you establish procedures in the Federal Radiation Council to give the American people impartially the full facts regarding any accidental release of radiation in the atomic energy industry.

Respectfully yours,

WALTER P. REUTHER, *President.*

Mr. GOODMAN. The Federal Radiation Council and the AEC should be obligated to advise the Joint Committee in a written report of each major radiation accident.

Another aspect of the safety problem is the need for uniform labeling and designation of radioactive materials in transit.

In this connection, I have a copy of the handbook of Federal Regulations applying to transportation of radioactive materials. What I am talking about is in this document. I would leave that for the Committee, if I may.

The United States participated in a series of programs starting in 1953 in the International Labor Office and through other affiliates of the United Nations in seeking an International Agreement on Uniform Radiation Symbols, and regulations regarding designation of radioactive material. An agreement has been approved all the way up through the Economic and Social Council of the United Nations. The United States supported and voted for this agreement but the Atomic Energy Commission and its industrial supporters are seeking support for the continuance of the propeller symbol here in the United States in the face of a more general agreement throughout the rest of the world on a more significant symbol. I hope this committee will ask for the full facts on this aspect of international agreement in this matter.

In conclusion, at a recent meeting of the atomic energy technical committee of the industrial union department, AFL–CIO, there was unanimous agreement in support of a traditional role of the National Laboratories. There was agreement that radiation standards and protection should be a continuing Federal obligation. We hope that section of the act passed last year will be repealed. There was

agreement that the AEC's 10-year program would provide us "too little and too late."

And finally, I was instructed to urge this committee to take some action to meet the workmen's compensation problem raised by this new science.

Representative HOLIFIELD. Referring back to the previous paragraph, what is the conflict there?

You say that the Atomic Energy Commission and its industrial supporters are seeking support for the continuance of the propeller symbol. What was the other symbol? A more dangerous looking symbol?

Mr. GOODMAN. Yes, sir.

Nobody knows what that means. That is the one.

Representative HOLIFIELD. This is the propeller symbol.

Mr. GOODMAN. Yes. This is ILO report on what the alternative agreed to by the United Nations Council was.

Representative HOLIFIELD. This is somewhat on the order of labeling a degree of radiation as a sunshine unit.

Mr. GOODMAN. Yes, very much. We have had many cases where packages containing radioactivity have come into the receiving room or shipping room of a plant with this label and workers had no idea what it meant and went to work and opened the package.

Representative HOLIFIELD. There have also been incidents, I might say, where radioactive waste material has been shipped without any kind of symbol on it.

Mr. GOODMAN. Yes. There was a case in Los Angeles where it was shipped without anybody being there to receive it.

Representative HOLIFIELD. That is right.

Mr. RAMEY. Mr. Chairman, may I comment on this "too little and too late"? We have heard some characterize the AEC program with the words "Nothing new 'till '62".

Mr. GOODMAN. At least there is alliteration there.

Representative HOLIFIELD. This is a period of enforced stagnation that is being advocated, where we will stop, look and listen for about 3 years and not make any new starts.

Mr. GOODMAN. I have great faith in the vigorous leadership of this committee.

Chairman ANDERSON. That is the finest note you could end on.

Mr. GOODMAN. I end right there.

Chairman ANDERSON. We take all these compliments even late in the day.

Thank you very much, Mr. Goodman. Thank you for that continued interest in this program that you have demonstrated through the years.

Mr. GOODMAN. Thank you very much.

Chairman ANDERSON. Our next witness is Mr. Steldt, of Minnesota Mining & Manufacturing Co. You may proceed, sir.

STATEMENT OF FRANK A. STELDT, MINNESOTA MINING & MANUFACTURING CO., ST. PAUL, MINN.

Mr. STELDT. Mr. Chairman, I am Frank A. Steldt of St. Paul, Minn., appearing on behalf of Minnesota Mining & Manufacturing

Co. of St. Paul. I wish to make a statement for the record as follows:

Minnesota Mining & Manufacturing Co. has for some time been carrying on research on a very substantial scale in a number of areas involving utilization of atomic energy. Two of the important areas in which such research is being done by 3M are the fields of high temperature reactor materials and the utilization of radioisotopes. As a result of this research, several unique developments of very practical importance have been made.

Minnesota Mining & Manufacturing Co. has paid the entire cost of facilities and manpower utilized in this research effort. The total amount expended by 3M in this effort to date is over $2 million.

Minnesota Mining & Manufacturing Co. has had a number of requests from the Atomic Energy Commission and its contractors to consider carrying out research and development in the field of utilization of atomic energy. These have consistently been turned down by 3M because of the implications of the Atomic Energy Act of 1954. Minnesota Mining & Manufacturing Co. has, as is well known, been extremely active in research and development work in a number of areas, which has resulted in many new products of great value. 3M's widespread research efforts are directed to a large extent to projects which have as one incident the accrual of significant technical know-how in which 3M has proprietary rights, as well as patents.

The language of the Atomic Energy Act of 1954, particularly the part of the act relating to patents and inventions, as interpreted by the Atomic Energy Commission, is believed to be unnecessarily severe and restrictive. It is considered by the 3M Co. that important parts of the accumulated proprietary rights and background patents acquired by 3M at great expense in the past would be jeopardized if 3M were to enter into a contract to carry out research for the Atomic Energy Commission.

It is pointed out that the language of section 152 of the act, which requires that—

> Any invention or discovery useful in the production or utilization of special nuclear material or atomic energy, made or conceived under any contract, subcontract, arrangement, or other relationship with the Commission, regardless of whether the contract or arrangement involved the expenditure of funds by the Commission shall be deemed to have been made or conceived by the Commission—

is so broad as to make it questionable whether 3M could retain or protect any of its rights in this area.

Section 31(c) of the act requires that contractors must permit publication of all technical information except that which is classified.

Mr. RAMEY. I think the Commission has a waiver provision in that section, as I recall.

Mr. STELDT. That is possible.

Mr. RAMEY. The Commission by rule, I believe, has issued language that would exempt under 152 for example, and make subject to bargaining, where a company has established a patent position prior to the time it enters into a contract and thereby to protect the patent rights the company has acquired. That is the normal practice that they have indulged in for years.

Mr. STELDT. Yes, sir. However, it is true that the Commission, I believe, requires that proprietary information and background infor-

mation be supplied whenever it appears that the particular subject matter may be of use in the reactor program because they feel they need to have alternate sources of supply. I think this is a very strong consideration.

Mr. RAMEY. I think in that connection, however, that is not a matter of law or the statute but a matter of bargaining on the Commission's part in trying to get the best deal they can as a Government agency.

In the Commission's testimony last week they indicated they expected to relax that type of bargaining endeavor to be a little fairer with prospective contractors.

Mr. STELDT. Minnesota Mining & Manufacturing Co. would certainly welcome that relaxation.

Representative HOLIFIELD. This requirement that you speak of for trade information and trade specifications and drawings and so forth is also a requirement by the Navy?

Mr. STELDT. Yes.

Representative HOLIFIELD. The Navy is particularly alert to that point. I have some cases where in my opinion the Navy has defrauded private people by insisting on this particular feature that you are speaking of.

Mr. STELDT. Yes. I will refer later in my statement to the Armed Services Procurement Regulations. These have now been amended as of October 1958 to permit that proprietary information be referred to in such a way that it does not enter the reports and so on. I think that is an improvement in that particular part of the picture.

Representative HOLIFIELD. I did not quite get the point.

Mr. STELDT. In the Armed Services Procurement Regulations, which I think the Department of Defense has been using in contracts for research and development, there has recently been a change which permits the contractor to refer to proprietary information by code numbers identifying the source or other suitable arrangement so that the information does not enter the reports and become disseminated to other contractors or to the general public.

Representative HOLIFIELD. I have in mind the case of an American concern that was making a certain article for the Defense Department. The Defense Department, notwithstanding this was a proprietary item, required him to submit his complete specifications and drawings for this device. They made copies of his drawings and made them available to at least two embassies of foreign nations on request. The embassies then sent these drawings overseas to their own nation's manufacturing plants and that nation's manufacturing plant, by the use of these drawings, was able to put in a bid on offshore procurement which outcompeted the American manufacturer. It put the American manufacturer out of business.

That is what it did in this particular item. By this devious method of obtaining proprietary specifications and drawings, it enabled the foreign company to make a successful bid against the American manufacturer who had developed these drawings with his own money. This was not under a national defense contract. This was a privately developed patent right.

Mr. STELDT. Yes. I am sure that everyone would believe that where a company has expended its own funds in developing a particular device, certainly a simple, contract for sale to the Armed Forces

should not require the distribution of drawings and other technical information to persons who can compete with that particular manufacturer.

The language of the act as interpreted by the Commission, so far as can be determined from published information, presently appears to require that any company entering into any relationship with the Commission must give up all rights to patents or proprietary information which may be obtained thereunder, except for the possibility of obtaining a nonexclusive license, as well as rights to background patents and proprietary information which are deemed necessary by the Commission, even though the latter resulted from privately financed research.

The Atomic Energy Commission's licensing provisions, which limit the amount of special nuclear material which may be in the posession of a licensee to quantities suitable only for research purposes unless the licensee has a contract with the AEC, seriously prejudice and tend to retard and restrict 3M's future research. If the contract thus required is interpreted as coming within section 152 of the act, 3M could not utilize its own technology commercially without giving up its proprietary and patent rights, which have been paid for privately and exclusively by 3M, to the AEC and all others, including any foreign country approved under chapter 11 of the act.

Minnesota Mining & Manufacturing Co. would like to make a contribution to the national effort in the field of atomic energy, as well as to increase its own research in this field. However, the 3M Co. has reluctantly come to the conclusion that unless the Atomic Energy Act of 1954 in its provisions relating to patents, inventions, and proprietary information is amended by legislation at least to the extent required to bring its basic patent and proprietary information policies into alinement with the policies now effective in research and development contracts entered into by the Department of Defense (Armed Services Procurement Regulations), 3M will find it most difficult to enter into any relationship or contract for research or development with the Atomic Energy Commission.

3M's policy has always been that of cooperation with the Government in fundamental research work wherever possible. It is noted that 3M presently is carrying on a large research effort for the Department of Defense under the Advanced Research Projects Agency. The provisions of the contract under which this work is done are those of the ASPR and include the grant of nonexclusive, royalty free rights to the U.S. Government in inventions made under the scope of the work.

In addition to these regulations, proprietary background information is protected from disclosure to others.

It is submitted that unless the provisions of the Atomic Energy Act of 1954 are made less burdensome, the United States may be deprived of the benefits of privately financed research in the field of atomic energy.

Chairman ANDERSON. Let me just say to you that I think you would possibly get a little different idea of the patent situation if you discussed it either with an attorney for the Atomic Energy Commission, or with Mr. Toll, who is counsel for this committee.

Some of the things in this we would be inclined to argue with you a little bit about but that would not help since neither Mr. Holifield nor I are lawyers. We are not lawyers at all. But I do think this patent situation is extremely difficult.

Mr. STELDT. Yes, it is.

Chairman ANDERSON. We tried very hard to work out a rearrangement of the law and we ended up by putting in four or five words extending it for another 5 years because it was a very difficult problem. I think it would be well for you to discuss with Mr. Toll, and Mr. Ramey, who is also a lawyer, and with the people at the Atomic Energy Commission, what their practices have been, because it would seem that they have been reasonably fair with Westinghouse, General Electric, Babcock & Wilcox, and big firms of that nature. I think Minnesota Mining & Manufacturing might decide to get along, too.

Thank you for being here and we appreciate your statement.

Representative HOLIFIELD. I would like to say, if I might before you conclude, Mr. Chairman, that these figures—I will correct them if I am wrong—the number of patents filed by people working under contracts with Atomic Energy Commission in the last 3 years has gone from about 200 a year to 600 a year.

Mr. TOLL. I think that is people working independently of contracts with the AEC indicating that there are patent applications being filed by persons using privately funded research and development. If one follows that approach it is possible to get a private patent. You recognize that, do you not?

Mr. STELDT. Yes.

Mr. TOLL. If you put up your own money you can get a patent.

Mr. STELDT. Yes; we understand that.

Representative HOLIFIELD. The restriction of the act, as many of us see it, is that where the Government puts up the money for research and development we only want the Minnesota Mining & Manufacturing Co. to do the same thing that you require an employee to do under your contract of employment; that is, to sign away your rights to patents that are developed under moneys of taxpayers. All we are asking you to do is the same thing you demand your employees do. Each of your employees have to sign a contract that if they think of anything during their term of employment, they jeopardize their personal proprietary rights to it while they are accepting a salary from the Minnesota Mining & Manufacturing Co. We feel it is just about as equitable for the Government to require you to sign away your rights when you are doing research and development which the Government pays for. But I would strongly take the position that the Government should not defraud you of any patent which you have or background patent rights which you have and which you have obtained by the expenditure of your money.

Mr. STELDT. Yes. I am sure Minnesota Mining & Manufacturing Co. would agree with you that what the Government pays for it should receive.

Representative HOLIFIELD. No; they won't agree with me. They want a scoop just like the Air Force and Defense Department gives to every one of the manufacturers to scoop out every benefit they can get out of a research and development project.

The American taxpayer's money has built up the patent ownership in the defense field to a tremendous extent because of loopholes bigger than that door for the companies to obtain patents as the result of their research and development contracts which they can use in their own business and charge other people royalties for. These patents have been developed due to moneys they have received from the U.S. Government.

Mr. STELDT. Mr. Holifield, may I comment here that perhaps that is true in the case of companies who receive substantially all of the money that they get for their products from the Government or from commodities which are used by the Government. But in the case of Minnesota Mining & Manufacturing Co. the research and development which is done for the Government is a minor part of the research and development done.

Representative HOLIFIELD. My remarks do not apply to the part where you finance your own research and development work. I am only referring to those companies that have obtained tremendous benefits as the result of doing Government work. They received their contracts and they have been paid a percentage of profit for the work which they have done; and, in addition, they have obtained windfall benefits through obtaining patents as the result of that work which has carried over into their other fields of endeavor.

Mr. STELDT. I must say I am not aware of the patent situation they find themselves in. But I would like to point out, however, that in those cases I think it is known that the facilities, in addition to the time spent, are paid for by the Government in many cases, whereas in the case of Minnesota Mining & Manufacturing Co., it uses the facilities which it already has in carrying out this research. So it is not a question of building up something for the company necessarily when it does this research and development for the Government.

Representative HOLIFIELD. It may not be in your particular case, but I know of many companies whose activities are almost 100-percent Government defense contracts and who have built up areas of patent advantage for their other operations.

Mr. STELDT. Could I introduce Dr. J. R. Johnson, of Minnesota Mining & Manufacturing Co., the director of the technical effort in connection with the 3M company's atomic energy program.

Chairman ANDERSON. Yes.

Dr. JOHNSON. I merely want to say we are on your side with respect to your last statement.

Representative HOLIFIELD. You signed a contract that, if you thought of anything while working for Minnesota Mining & Manufacturing, it belongs to them?

Dr. JOHNSON. That is right. We have scrupulously avoided accepting Atomic Energy Commission money in the atomic field, and therefore we feel we are entitled to those things which we have developed; however, the way the law reads, we have come to the crossroads as to what is a relationship with the Commission or what is an arrangement with the Commission. Obviously, where we have developed something which is useful to certain Commission facilities—and I can name many of them—they have wanted to test our materials or try them out. Does this constitute an arrangement or a relationship with the Commission by which our rights can be taken from us?

Chairman ANDERSON. We are very hopeful that we will have a chance sometime to clarify that language. Therefore, we will be happy to have any suggestion that you want to make. I want to say to you that in writing the 1954 act we spent an entire day one time on a single work. I found out then it is a difficult problem to make all the lawyers agree on any one particular set of words. It probably will be the same on this. We are very glad to have your suggestions. If you have a suggestion for language we will accept it at any subsequent date.

This will conclude the Joint Committee on Atomic Energy 202 hearings. We expect to supplement the hearing record by asking the AEC to answer the questions which the chairman of this committee raised in his opening statement. We expect to discuss the AEC's 10-year atomic power program at greater length during the authorization hearings which will be presided over by Mr. Holifield March 8 to 10 and April 5 to 7. We appreciate the attendance of people who are here and the contributions that have been made.

Mr. HOLIFIELD. Mr. Chairman, before we adjourn, the record will be open to submissions by different companies on pertinent subjects for the printed record.

Chairman ANDERSON. Yes; it will be.

Representative HOLIFIELD. For another period of time?

Chairman ANDERSON. For about 2 weeks is the general rule.

Thank you very much.

(The following statements were submitted for the record:)

AEROJET-GENERAL CORP.,
Azusa, Calif., February 15, 1960.

The Honorable CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
U.S. Capitol, Washington, D.C.

DEAR SENATOR ANDERSON: The following statements are respectfully submitted for the record in connection with section 202 of the Atomic Energy Act of 1954, as amended, on the "Development, Growth, and Future of the Atomic Energy Industry."

ARMY GAS-COOLED REACTOR SYSTEM'S PROGRAM (AGCRSP)

The principal nuclear activity of Aerojet-General Corp., at present, is in connection with the Army gas-cooled reactor system program, AGCRSP. This development program represents a joint effort by the Atomic Energy Commission and the Army Corps of Engineers to develop a nuclear-powered, field electrical generating plant. Col. Donald G. Williams, of the Army Corps of Engineers and the Army Reactors Branch, AEC, has taken a leading role in determining the specifications and the mission that this powerplant will fulfill. The Army Reactors Branch of the AEC designated Idaho Operations Office, under the direction of Mr. Allan C. Johnson, to coordinate this program and to administer the contract.

Aerojet is overall systems contractor for this program, and is responsible for developing a closed-cycle, gas-cooled, mobile nuclear powerplant in the 300 to 500 kilowatt (electrical) range. The plant will be readily transported by aircraft, rail, or standard Army trailer.

The objective of the AGCRSP is to deliver a set of specifications and fabrication drawings of the field model of the nuclear powerplant by May 1962. This unit, designated the ML–1A, will be put into production shortly after this date.

Basically, the ML–1A consists of four skid-mounted units: (1) Reactor assembly, 15 tons; (2) power-conversion equipment, 15 tons; (3) control cab, 2.5 tons; and (4) auxiliary components, 6 tons.

In developing the ML–1A, steps have been taken to assure a logical evolution of technology. The reactor characteristics are being investigated in the gas-cooled reactor experiment I (GCRE–I) soon to go into operation at the National Reactor Testing Station (NRTS) in Idaho. The power-conversion equipment is being investigated in the Gas Turbine Test Facility (GTTF) in the U.S. Army Engineering Research and Development Laboratories, Fort Belvoir, Va. Information from both of these facilities will be integrated and used to design and fabricate the ML–1A (mobile, low-power, prototype unit 1). The ML–1, to be put into operation at NRTS by mid-1961, will be a skid-mounted unit. and will be prototype to the ML–1A in most characteristics.

Aerojet first entered this program in November 1956 when it was awarded a contract to determine an optimum development program for the GCRE–I. This contract was later extended to include the design and fabrication of the GCRE–I reactor, controls, fuel elements, and instrumentation. The responsibility for the reactor test facility and the gas loop design was awarded to Aerojet's architect-engineer group at Covina, Calif.

The GCRE–I is a heterogeneous, water-moderated, nitrogen-cooled reactor operating at a nominal thermal power of 2.2 megawatts. The heat produced by the reactor is expended through a heat exchanger and cooling tower, inasmuch as only reactor components are being tested at this facility.

Aerojet's Architect-Engineer Division was awarded a contract to supervise the construction of the GTTF at Fort Belvoir. The GTTF was based on a design prepared by the firm of Sanderson & Porter in 1956. Aerojet's contract was amended early in 1959 to include acceptance testing of the GTTF. Since the GTTF is designed to provide information about the power-conserion equipment only, the nuclear heat input is simulated to by oil-fired heater. The principal components being tested include the turbine-compressor set, a recuperator, a precooler, and a generator. The Facility has recently been operated on an open-cycle test and is now being prepared for closed-cycle testing.

The next phase in developing the ML–1A is to design, fabricate, and operate a prototype plant which is designated as the ML–1. This plant will be put into operation in the first half of 1961 at the NRTS in Idaho. It has been specified that, insofar as possible, this unit will be a prototype. As such it will provide valuable information on the operating potential and characteristics of the final field unit.

The ML–1 is a heterogeneous, water-moderated reactor. The fuel elements are of the pin type, clad with a nicke]-base alloy, and contain ceramic UO_2 fuel. The power-conversion equipment for the ML–1 is rather unique in that it will be the first application of the high-temperature, closed, gas cycle to nuclear power production in this country. The more normal approach to produce electrical power from nuclear reactors is to use the so-called two-cycle system; one in which a primary coolant flows through the reactor, is heated, and then routed to a heat exchanger which converts water to steam. The steam then is used to drive normal steam power-conversion equipment. In the closed-cycle gas system, the gas is directed from the reactor into the turbine without undergoing any intermediate step. The turbine directly drives an alternator and produces electrical power.

This concept offers several advantages because of its simplicity and overall system efficiency. These advantages are extremely important to the Army for mobile, low-power applications now under consideration. Some of the specifications of this nuclear powerplant are listed below and apply to both ML–1 and ML–1A.

Electrical power output	400 kw (gross).
Reactor thermal power	3.4 mw (total).
Gas temperature:	
Reactor inlet	800° F. (nominal).
Reactor outlet	1,200° F. (maximum).
Distance of control cab from plant	500 feet.
Dose rate at cab during operation	5 mr/hr.
Maximum operating crew size (24-hour-day operation).	7 men.

The ML–1A has distinct advantages over stationary, or portable, nuclear powerplants in that it can be relocated 24 hours after shutdown, and can be placed in operation 12 hours after its arrival at a new site. The power packages are readily transported by C–133, C–124, and C–130 aircraft, by the Army's M–172A trailer.

and by rail. This permits the ML–1A to be used for a variety of military field applications. Some typical uses are:

Advanced field hospitals.
Remote missile bases.
Radar stations.
Emergency power (e.g. for civil defense).

Being independent of fuel supply, the ML–1 offers logistic advantages not available with conventional powerplants. An additional advantage is the small crew required to maintain and operate the powerplant. This results in additional savings in terms of the logistic support required.

In general, things are going quite well on this program. It is expected that the GCRE–I will go critical at Idaho in the near future, and preliminary testing of the reactor is scheduled thereafter. The gas turbine test facility has operated on open-cycle testing of the turbine-compressor set, and the facility is now being prepared for closed-cycle operation. Two in-pile tests have been completed for the reference fuel element, supported by extensive out-of-pile heat transfer and materials testing. From this information it appears that the current ML–1 fuel element is capable of achieving a lifetime of about 3,000 hours. Advanced versions of this element will achieve the design goal of 10,000 hours.

The ML–1 design and fabrication is proceeding on schedule, and there is now no reason to believe that the criticality date of April 1961 will not be met.

Aerojet feels extremely fortunate in being able to participate in this vital program for the Army and is grateful for this opportunity to review the program and to report its status.

CHEMONUCLEAR REACTORS

At the present time atomic energy is important for such military applications as weapons and propulsion systems. The principal program for peaceful use of atomic energy is central electrical power stations. To date the use of radioisotopes has been recognized as the principal nonpower peaceful use of atomic energy. However, our studies indicate that the use of nuclear reactors for directly converting fission energy into chemical energy could also be of major importance. Reactors of this type have been named "chemonuclear reactors." Our system is not only technically feasible but also potentially economically profitable.

A chemonuclear reactor concept involves the operation of a nuclear reactor in which the fissioning fuel is in intimate contact with a chemical reactant stream. Its possible import to the combined nuclear and chemical field can best be discussed in terms of a particular product—nitric acid.

Nitric acid production in the United States alone is some 3 million tons per year, and is worth nearly $300 million. Three-fourths of this is used as fertilizer. This industry is, roughly, one-tenth the magnitude of central station electrical power industry. Also, roughly one-tenth as much fossil fuel is currently used in making nitric acid as is used in central station power.

The average rate of growth of the nitric acid industry in the United States exceeds 6 percent a year. Production of nitric acid using fission energy could require the construction of approximately three 100-megawatt plants per year to match this growth rate. At this time it appears that a reactor might be developed to supply nitric acid to consumers at lower costs, thereby increasing the rate of consumption appreciably, and therefore the yearly requirement for nitrogen reactor plants.

The search for chemical applications of atomic energy is not a new one. Since operation of the first nuclear reactor, the application of the energy released to chemical production has been a topic of general discussion. Most proposals have suggested using the energy evolved either as process heat or as ionizing radiation. In the process heat concept, nearly all of the energy liberated is available, but at temperatures limited by the properties of construction materials. Thus the energy is degraded to relatively low temperatures before application to the chemical system, and process and economics suffer accordingly.

The ionizing radiation concept utilizes energy at densities equivalent to temperatures of 10,000° K. Furthermore, the products formed under these conditions are automatically cooled to any desired ambient temperature within millionths of a second. They are thus prevented from decomposing and are preserved in a desired form. However, this approach is severely limited in overall

efficiency by the fact that less than 7 percent of the fission energy is liberated as ionizing radiation.

The ideal system would be one which combined the advantages of these two techniques without suffering from their disadvantages. Such a system was demonstrated by Harteck and Dondes working under an AEC contract at the Rensselaer Polytechnic Institute in 1956 when they used fission fragment recoil energy to combine nitrogen and oxygen, i.e., nitrogen fixation, as nitrogen dioxide. The efficient utilization of this technique requires that the two or more fragments resulting from the fissioning of a uranium atom be allowed to recoil through a chemical reactant stream. Most of the energy liberated by fissioning is carried by these rapidly moving fragments, and this energy is deposited as heat in the chemical stream. The high temperature resulting is utilized to bring about the desired reaction. No intermediate energy transfer steps are required, and thus relatively high efficiencies are attainable.

A commercial unit based on this concept is envisioned as an integrated plant with self-contained decontamination and product purification steps associated with the nuclear reactor. In the specific case of a nitric acid plant, only air, water, and a small amount of uranium will be fed to the plant. The output will be pure, uncontaminated nitric acid and small quantities of concentrated radioactive waste. This nitric acid will be comparable in every way to that produced and consumed today. Since the production reactor is of inherently safe design and the routine processing of megacurie quantities of radioactivity is not novel, such a plant may be located at almost any site suitable for a routine chemical production facility.

Historically, Aerojet's interest in chemonuclear plants (particularly in the nuclear nitrogen fixation reaction) stems from a joint study cosponsored by the Union Stock Yard & Transit Co. of Chicago, a major producer and user of nitric acid because of its fertilizer interests. Reasonable engineering assumptions applied to the initial Harteck and Dondes concept resulted in a preliminary nuclear nitrogen fixation plant design and cost estimate indicating an economically competitive process.

A preliminary experimental study of the central process concept was then carried out by Aerojet under the sponsorship of the AEC. During this program anticipated commercial reactor conditions were duplicated in a small loop capsule which was irradiated in the Livermore pool type reactor. The resulting nitrogen fixation yields were substantially greater than had been assumed in the initial plant design study mentioned earlier.

Much research and development remains to be done, of course, before commercial construction can begin. Aerojet is presently negotiating with the AEC for further R. & D. funds. At the moment reasonable engineering estimates predict that a 94-megawatt reactor would produce 107,000 tons of nitric acid per year. In determining the ultimate economics of this process, the research, development, and plant design costs associated with the first plant have been excluded. On this basis, the total capital cost of such a plant is estimated at $21,500,000. Operating costs at normal capacity are estimated at $25.90 per ton of nitric acid. If the current market value of nitric acid (circa $78 per ton) is assumed, a net annual return of $5,580,000 is available for retirement of the investment.

The goals to be achieved by such investigations may not be solely economic. For example, nitrogen fixation is normally based on the hydrogen-ammonia-nitric acid-fertilizer chemical chain. Large, populous sections of the world have little or no petroleum refining capacity and are thus denied easy access to the byproduct hydrogen necessary for this process. With fertilizer essentially unavailable, agricultural productivity is low. In these areas, the advent of nuclear nitrogen fixation could result in readily available fertilizer at a total raw material expenditure of less than 2 grams of uranium per ton of fixed nitrogen. It is estimated that an intensive research and development program could lead to process commercialization in the mid-1960's at a reasonable cost.

While production of nitric acid is by no means the sole capability of such a system, this goal in itself is important enough to demand urgent consideration of this approach to using fission energy for chemical production.

Sincerely yours,

DAN A. KIMBALL, *President.*

AMERICAN ELECTRIC POWER CO., INC.,
New York, N.Y., March 14, 1960.

The Honorable CLINTON P. ANDERSON,
Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR SENATOR ANDERSON: In accordance with correspondence with you under dates of January 20 and February 3 and Mr. Ramey's letter to me of February 11, I am submitting the following statement for your section 202 record for this year. The statement is submitted by me as chairman, Research and Development Committee, East Central Nuclear Group. It relates to the project for a 50-MWe advanced gas-cooled D_2O moderated reactor of the pressure tube type intended for construction by the Florida west coast nuclear group. All this experimental work, as you know, is for a prototype of a full-scale plant capable of operating on natural uranium fuel.

As I explained in my letter to you of February 3, a responsible statement to your Committee on this project had to encompass essentially the same ground as the semiannual report to the Atomic Energy Commission which was then in process of preparation. The report in question has now been completed and delivered to the Atomic Energy Commission. This statement sets for the principal findings and conclusions of the report. Naturally, the report itself is much more detailed.

In this statement I shall first describe the status of the research and development program, then the present prototype cost estimates, and next the initial cost estimate on a full-scale 300-MWe plant. Finally I shall attempt to assess the favorable and unfavorable conditions which have been encountered and describe the recommendations we have made to the Atomic Energy Commission for the future of the project.

RESEARCH AND DEVELOPMENT PROGRAM

The greater part of the work in the research and development program for this project is proceeding as planned. Conceptual design and engineering studies which have continued include: work to insure that the prototype design includes all necessary safety provisions; work to obtain a more reliable cost estimate on the prototype; and initiation of work leading to a preliminary conceptual design and cost estimate for a 300,000-KWe nuclear plant.

The work to date has uncovered no indication of technical infeasibility. However, delays have been encountered in certain activities considered vital to a determination of technical feasibility. In consequence of these delays the projected date for the prototype reactor to go critical (approximately June 30, 1963) can no longer be regarded as realistic. For every month of delay beyond July 1960 for the determination of technical feasibility, the projected date for the prototype reactor to go critical would probably be deferred 1 month. Most of the critical testing can in all probability be completed by the fall of this year. But certain critical items of work, namely, in-pile testing of fuel bundles and selection of an acceptable pressure tube flow liner, are not likely to be finished by that time; at the earliest, this critical work cannot be completed until the end of this year and possibly later. However, it is now believed that by September 1960 it should be possible to reasonably estimate terminal dates for conclusion of all the research and development program necessary to determine technical feasibility.

PROTOTYPE COST ESTIMATES

In our original proposal for this plant in December 1957 we gave a very preliminary estimate of the capital cost at $25,885,000. As work proceeded on estimates, a number of important uncertainties with respect to capital items led us to report to the AEC in September 1959, that the cost of the prototype would range between $24,954,000 and $30,830,000.

We have now refined those projected prototype costs so that our present estimate is $29,391,000. This figure is the best estimate made to date for the prototype as designed, and we believe that the actual cost of such a prototype would vary only slightly above or below this figure.

Fixed charges for the prototype have naturally risen sharply with the increase in estimated capital investment. Annual nuclear fuel expenses, another major item, would be approximately the same as the lower range reported to

the AEC in September 1959—but that figure was already considerably higher than that estimated in the original proposal. Hoped-for reductions in cost have not materialized.

The target energy cost, computed in accordance with the terms of the contract with the AEC, is now estimated at 12.05 mills per kilowatt-hour. The computation of target energy cost in the original proposal was 12.27 mills per kilowatt-hour. These target costs vary only slightly because while capital costs for the hypothetical conventional plant used for computing the target have increased, offsetting reductions have occurred in conventional fuel costs in Florida. But the prototype energy costs, reflecting the increases both in capital investment and in fuel and other items, are now estimated at 14.75 mills per kilowatt-hour.

A comparison of prototype energy cost estimates as presented in the December 1957 Proposal for Cooperation With the Atomic Energy Commission for the Development of an Advanced Gas-Cooled D_2O Moderated Pressure Tube Reactor, the September 1959 Consideration of Technical Feasibility and Prototype Energy Costs, and the present estimates are shown in the following table:

Cost estimates

[In thousands of dollars]

Item	December 1957 proposal	September 1959 report projections		March 1960 estimate
		Lower	Upper	
Prototype capital investment	25,885	24,954	30,830	29,391
Annual capital expenses	2,786	2,728	3,341	3,285
Annual D_2O expenses	134	156	156	195
Annual operating costs	758	580	859	807
Annual fuel expenses (3d, 4th, and 5th years)	647	1,114	1,404	1,101
Annual AEC waivers	160	254	254	213
Net annual expenses (3d, 4th, and 5th years)	4,165	4,323	5,506	5,389
Net energy costs, mills per kilowatt-hour	11.90	12.35	15.73	14.75
Target energy costs, mills per kilowatt-hour	12.27	11.78	11.78	12.05
Average conventional energy cost to FWCNG, mills per kilowatt-hour	9.4	9.4	9.4	8.7
FWCNG operating deficit (1st 5 years operation)	5,426	6,092	11,897	12,264

It is now clear that the target cost cannot be met by the prototype, and that if the prototype is to be built, new arrangements will have to be made to defray the increased costs. Our comments with respect to the problem of prototype cost appear in the final section of this statement.

FULL-SCALE 300-MWE PLANT AND ITS COST ESTIMATE

In reporting the status of the prototype, it is necessary to emphasize the relationship between the prototype and the full-scale plant. Particularly, it should be noted that stainless steel clad fuel elements for a prototype are strictly a stopgap solution. In designing a prototype, stainless steel cladding was adopted in order to make possible a construction schedule for a prototype prior to the perfection of beryllium technology which may be some years off. The basic concept of this reactor requires a high-temperature fuel clad of low-neutron absorption material. Type 347 stainless steel is acceptable as a high-temperature material, but it is unacceptable on the neutron absorption point.

It always has been the intention of this project to exert a sizable effort to demonstrate the feasibility of using metallic beryllium as the high-temperature, low neutron-absorption cladding material. The problems with beryllium are several, and so far only one of these has been directly approached by our project. This problem, which has to do with the formation of helium gas due to fast-neutron bombardment of beryllium, is being investigated by an experiment in the Oak Ridge Research Reactor. We anticipate in this experiment, which involves irradiation of beryllium under controlled temperature conditions with a large, fast-neutron flux, will yield a specific answer to this question. There is increasing confidence that the answer will be favorable since the fuel elements of the British high-temperature reactor are now being fabricated with beryllium metal clad. Details of the British experiments on the gas genera-

tion and entrapment due to fast-neutron bombardment are not known, but at least some British designers have concluded that such irradiation does not prevent the use of beryllium for high burnup fuel elements. Apparently other problems involved in beryllium technology, such as ductility which affects the drawing of tubing and recrystallization of weld zones which affects closures, have been satisfactorily solved. In the light of this evidence there seems to be good expectation that beryllium clad fuel meeting the specifications of high-temperature, low-neutron absorption can be realized.

(In view of the considerable progress which has been made in obtaining alloys of zirconium which withstand destructive attack by hot carbon dioxide, there is also the possibility that further research on such alloys would yield one suitable for use as a fuel jacket. Presumably, a zirconium alloy would be less costly than beryllium metal and therefore would be preferred. Since no such alloy is known, it can only be a matter of speculation now, but there is the definite possibility that research on the properties of suitable zirconium alloys would be rewarding.)

Assuming that beryllium technology can be applied to fuel element construction, an analysis of the fuel cost for this reactor for natural uranium and near-natural uranium has been made. This analysis supports the view that lowest fuel costs will be realized when enrichment is used for the extension of burnup only. The following tabulation shows the sharply favorable effect of fuel enrichment on estimated fuel cycle costs:

Fuel enrichment (percent)	Fuel exposure (MWD/ton U)	Fuel cost (mills per kwh)
Natural	6,000	2.6
0.83	10,100	1.8
1.00	15,000	1.37
1.15	19,600	1.18

Low fuel cost by itself is significant and important for the future extension of the growth and use of nuclear power, as also is the ability of the reactor to operate satisfactorily on natural uranium, both from the standpoint of low fuel cost and from the standpoint of minimum refining operations intervening between the production of the basic fuel material and its use in the reactor. Plutonium recycle ultimately will be a desirable feature of nuclear power generation, and, in this case, the performance of the natural or near-natural uranium, low-temperature moderator reactor of this project is distinctly superior to all other types with the possible exception of the fast breeder. Comparison with the fast breeder really is not possible unless very specific ground rules are stated, especially rules concerning inventory charges.

The work that we have initiated during the past 6 months on a preliminary conceptual design and cost estimate for the full-scale plant has tended to confirm our view of the promising nature of this reactor concept. These preliminary cost estimates are 10.2 mills per kilowatt-hour for natural uranium and 8.8 mills per kilowatt-hour for only 1.15 percent enrichment. The following table shows cost estimates for several enrichments:

Enrichment, percent U–235	Natural	0.83	1.00	1.15
Cost item:		*Cost (mills per kilowatt-hour)*		
Fixed charges 14 percent, 80 percent capacity factor)		5.8		
Heavy water inventory (12.5 percent per year)		0.79		
Fuel-cycle costs	2.6	1.8	1.37	1.18
Operation and maintenance		0.93		
Heavy water makeup		0.06		
Total energy cost (mills per kilowatt-hour)	10.18	9.38	8.95	8.76

Our preliminary investigation and cost estimate at least indicate that the energy cost of this reactor concept may be comparable with those of other reactor concepts, although the limited extent of our study prevents a valid comparison with the costs reported in AEC documents TID–8504 and TID–8516, some of which are lower and some higher than those in our study.

CONCLUSIONS

Both ECNG's and FWCNG's interest in the prototype continues. FWCNG is still willing to assume a financial burden for such a plant up to 150 percent of a conventional plant energy cost as defined in the AEC contract. But the presently estimated protoype energy cost is approximately 185 percent of such a conventional plant. This means that even with FWCNG assuming the burden associated with the 150 percent, the cost differential reflected in the 185 percent figure would require assistance to FWCNG to place it in a position with respect to cost burdens comparable to that contemplated by the original proposal and the contract.

The interest of everyone concerned, despite the discouraging cost figures on the prototype, grows out of the attractiveness of the original concept when applied to a full-scale plant of 300,000 KWe. We believe, as stated earlier, that this concept has a number of distinct advantages and that it should be possible to incorporate these advantages economically in a full-scale plant. One of the most attractive features of the concept in full-scale application is the effect of fuel enrichment on estimated fuel-cycle costs: these estimated fuel costs bear repetition, ranging from 2.6 mills per kilowatt-hour using natural uranium, with a sharp drop to 1.18 mills per kilowatt-hour with only a slight enrichment to 1.15 percent.

It is also worth repeating that the attractiveness of this reactor concept depends ultimately on the development of beryllium or other low neutron absorbing material to use for fuel cladding. Although the successful development of this technology may be some years off, we think our research and development program is one of the essential prerequisites to use of beryllium fuel cladding.

In sum, we still strongly believe that the research and development program originally proposed is worthwhile and should be continued. Substantial research and development expenses are just now approaching, in which we share expenses with the Government. Research and development expenditures for calendar year 1960 are estimated to be of the order of $3,500,000. We are sharing these expenditures because we believe that the work should be continued to the point where technical feasibility of the concept can be determined. Should technical feasibility be established, and assuming continued promise for the full-scale plant, we would then be in the best position to explore solutions to the financial problem created by the increased cost of the prototype and its operation. Meanwhile, we shall try to find possible solutions.

Sincerely yours,

EAST CENTRAL NUCLEAR GROUP, INC.,
By PHILIP SPORN,
Chairman Research and Development Committee.

AMERICAN PATENT LAW ASSOCIATION,
Washington, D.C., February 17, 1960.

HON. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
U.S. Senate, Washington, D.C.

DEAR SENATOR ANDERSON: The American Patent Law Association desires to reaffirm its previous statement favoring a return of the atomic energy field to the normal operation of the patent system by repeal of Chapter 13 of the Atomic Energy Act of 1954. Such repeal would place the Atomic Energy Commission on the same basis as the Defense Department as regards its patent activities. Title 28, United States Code, section 1498, dealing with compensation to patent owners for the use of their inventions by the Government, and title 35, United States Code, sections 181 to 188, regulating in detail patent aspects of inventions with respect to which the national security is involved, would then apply in the atomic energy field as they now do in other fields. Such repeal would enable the AEC to regulate its own patent affairs having to do with procurement, by regulations analogous to the Armed Services Procurement Regulations, A.S.P.R. section IX, dealing with patents and technical data, rather than be controlled by the more rigid statutory regulations now in effect.

We refer you particularly to the statement filed at hearings before your committee on April 22, 1959, by Richard Whiting on behalf of our association and made a part of the record of such hearings.

We respectfully request the inclusion of this letter in the record of the hearings which will be held under section 202 of the Atomic Energy Act beginning February 16, 1960.

Respectfully yours,

CHARLOTTE E. GAUER,
Executive Director.

THE BABCOCK & WILCOX CO.,
ATOMIC ENERGY DIVISION,
New York, N.Y., February 15, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy, Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: Thank you for your letter of February 9 attaching a copy of part 4 of the Atomic Energy Commission's "Civilian Power Reactor Program Study." We are making a statement for the section 202 hearings, but touched only briefly on item 1 of the suggested topics.

We consider part 4 a good presentation of the AEC's plans for reactor development. In general, it is a well-prepared program.

As you would expect, we have some reservations on some of the concepts to be covered in the reactor program, but our competitors probably have similar, though different, reservations. I am confident, however, that aggressive action on the reactor program can give results which will yield commercially competitive nuclear power much earlier than some people think.

Sincerely,

L. M. CURRIE, *Vice President.*

STATEMENT OF THE BABCOCK & WILCOX CO. FOR THE FEBRUARY 1960 HEARINGS OF THE JOINT COMMITTEE ON ATOMIC ENERGY

The Babcock & Wilcox Co. appreciates the opportunity to submit a written statement to be included in the record of the hearings which the Joint Committee on Atomic Energy has scheduled in the period February 16 through 25, 1960. Our comments are directed to items 1 and 3 of the list of suggested topics attached to your invitation.

Under item 1, the AEC's 10-year civilian power program, the Babcock & Wilcox Co. is manufacturing equipment for the nuclear portion of the Consolidated Edison Co. powerplant to be located at Indian Point on the Hudson River, and it is our understanding that Consolidated Edison is forwarding a statement concerning the status of the work on the plant.

A very significant feature of this plant is its utilization of thorium in a large size power reactor. The work of the Babcock & Wilcox Co. leads us to believe that thorium utilized in an improved type of pressurized water reactor, including the use of heavy water in a moderator control system, can yield very good neutron economy.

Uranium 233 has an inherent advantage over plutonium as a fuel in thermal reactors because it releases more fission neutrons per neutron absorbed by the fuel. As a result, more neutrons are available for capture in the fertile material to make new fuel. The practical result of recycling U^{233} is to reduce the quantity of U^{235} required from the diffusion plants to produce a kilowatt-hour of electricity. In light water reactors recycle of plutonium can reduce the quantity of U^{235} required by about a factor of two, whereas recycle of U^{233} can reduce the U^{235} required by at least a factor of five. The moderator control reactor with thorium offers the possibility of a breeder reactor which would reduce U^{235} requirements to a minimum.

The potential of thorium as a fuel can best be evaluated after the comparative prices for plutonium and uranium 233 have been stabilized.

The significant factor in these prices will be the recycle costs. If the cost of recycle of both fuels is the same—and there is little reason to believe that one fuel will be cheaper to fabricate than the other since both plutonium and U^{233} require special handling procedures—it appears that the use of U^{233} would lead to lower fuel costs.

Unless fuels can be recycled economically, neither plutonium nor U^{233} will show a net credit for fissionable material produced. A strong effort in this area is therefore recommended, particularly for the U^{233} thorium fuel cycle. Also we feel that the relative prices for U^{233} and plutonium should be reevaluated and

changed, if necessary, in the light of new information which has been developed in the nuclear energy field in the last few years.

With respect to item 3, the maritime reactor program as it affects industry, we are continuing our work on the nuclear-propulsion equipment for the N.S. *Savannah*. All of the large pieces of equipment, pressure vessels, steam generators, pressurizer, primary pumps, primary piping with valves, turbines and reduction gears, have been delivered to the shipyard, and with the exception of the motors and impellers for the primary pumps, all have been installed in the vessel.

The fabrication of the reactor core has been completed. The actual core consisting of fuel elements, control rods and fuel container assembly, has been set up in the critical experiment laboratory in Lynchburg, and was brought to criticality on February 8 with nuclear performance as predicted. Zero power tests on the core are continuing, and shipment will be made upon completion of these tests.

Shipment of the control rod drives is scheduled for March.

As a result of our long interest in marine propulsion since our first shipboard installation in 1875, and more recently because of our participation in the building of the nuclear powerplant for the *Savannah*, we are very interested in the problems involved in the building of additional nuclear-powered ships.

Recently the Babcock & Wilcox Co. signed a 10-year agreement with Cantieri Riuniti Dell'Adriatico (United Shipyards of the Adriatic) permitting this large Italian shipbuilding concern to build and sell merchant vessels powered by nuclear propulsion plants based on Babcock & Wilcox designs, know-how, and patents. Under terms of the agreement, Babcock & Wilcox will furnish technical assistance to CRDA for nuclear-propelled ships to be sold both within and outside Italy.

The biggest problem in the operation of American ships today is one of economics. The cost of ship construction in this country is approximately twice that in foreign countries, and the cost of ship operation is higher under the American flag than under a foreign flag.

These differences in costs reflect the standard of living we have developed under the American system. It is part of our way of life and is therefore a fundamental consideration in the overall problem.

This problem exists whether the ship is driven by nuclear energy or by energy derived from fossil fuels. Therefore, we have the basic ship cost as the first part of our problem. This must be considered as it has been in the past under the subsidized program.

With nuclear power there is an additional cost differential. The nuclear equipment necessary to generate the steam requires costs considerably more than does comparable equipment burning fossil fuel. Principally for this reason the cost of a nuclear ship will be higher than a conventional ship, by 50 percent in special cases and even more in others, depending on the type of ship.

Against these higher capital costs there will be some savings. More cargo can be carried on a nuclear ship as less fuel is required. The cost of nuclear fuel may be slightly less than fossil fuel. At present these savings do not generally exceed 10 percent of the operating costs, and this is not sufficient to overcome the high capital costs.

When merchant ships are built and operated by shipping companies in business to make money, as is the usual case, capital costs and operating costs are or great importance. This is attested by the large number of American ships being built in foreign countries by American owners and later operated under a foreign flag.

There is the possibility that American capital may be invested in foreign-built nuclear ships with reductions in costs as compared to this country. If this should happen, foreign countries will probably design and build the equipment, with attendant loss of experience to American manufacturers.

If the United States is to build nuclear merchant ships, we must have a program. This program should provide assistance to private shipowners and operators in the same spirit as assistance has been provided in getting the civilian power program underway. The mechanics must be different because of the different economic conditions in the shipping industry.

We need first to determine the most likely applications for nuclear power. In general the larger and faster the ship and the longer its run the more nearly competitive is nuclear power. A large fast passenger ship may prove to be a worthwhile application for nuclear propulsion.

The United States needs a program which will select the proper applications, and will then provide the economic arrangements which will make it possible to build ships in the United States and operate them under the American flag. The program must include Government aid in construction and operating costs.

People who build and operate ships in the United States are ready to accept new ideas and designs. The ships which have been built are testimony enough. These ships compete against foreign-flag ships, and operate successfully under a well-established program. If a program for nuclear ships is also set up there will be a future for nuclear merchant ships in the United States.

L. M. CURRIE,

FEBRUARY 15, 1960.

ADDITIONAL STATEMENT OF THE BABCOCK & WILCOX CO. FOR THE FEBRUARY 1960 HEARINGS OF THE JOINT COMMITTEE ON ATOMIC ENERGY

We realize the complexity of patent situations where AEC funds are involved in research and development programs, and recognize that "foreground rights" present a knotty problem.

However, there are two areas—each causing many difficulties—where clearer statements of the law would be of great help. These two areas deal with "background rights" and/or rights to know-how developed independently of (though possibly concurrent with) a given AEC contract.

In the area of AEC contract policy, we have objected to the use of the phrase "in connection with" in the AEC standard patent clause as set forth in article 013 of chapter 9113 of the AEC Manual (copy attached), because we are uncertain as to what inventions may be covered by the phrase. Our attorneys are of the opinion that by accepting such broad and vague language, Babcock & Wilcox may be jeopardizing rights to inventions not made under any AEC contract but made during said contract term and at B. & W.'s own expense in its commercial business of boilers and reactors.

Recently we felt it necessary to stop doing some work for the Argonne National Laboratory (ANL) because during negotiations we could not get the AEC to remove the "in connection with" phrase from the patent rights article. The proposed contract called for B. & W. to run some $90,000 worth of tests for the experimental boiling water reactor (EBWR) at Argonne National Laboratory. The work would have extended over a period of more than 1 year, and would have utilized only know-how and techniques in handling circulation of boiling water—knowledge accumulated by Babcock & Wilcox over a period of many years.

Because of their extremely tight schedule for that reactor, we had started work immediately upon receipt of Argonne National Laboratory's request. After considerable expense to Babcock & Wilcox, and much effort, we stopped this work and thereby probably upset the Argonne National Laboratory schedule of criticality of the experimental boiling water reactor.

Decision for stopping the work was based on the vague language of the patent rights article, which we felt would cast a shadow on the title of any Babcock & Wilcox inventions or discoveries in the field of steam-water circulation and separation which might be made just prior to or during the term of the contract, even though outside of the contract work. As steam boilers are our traditional business, we felt we could not afford to jeopardize Babcock & Wilcox's rights to inventions and discoveries in that field.

AEC legal and patent people decided they could not delete the phrase to which we objected because they felt it required a waiver, of section 152 of the act of 1954, for the benefit of the contractor. In their opinion a waiver would be justified only in a case where the Government program would be seriously impaired. They apparently did not feel that the work stoppage would constitute a serious impairment of the Argonne National Laboratory program. (I believe the Argonne National Laboratory technical people felt otherwise.)

We believe that continued use of the term "in connection with" in the AEC standard article on patent rights will discourage other possible contractors from taking AEC contracts in fields of activity where the contractors have a commercial business and, presumably, have the kind of experience the AEC desires and needs. A study of this problem by the Joint Committee would clarify the situation and help both the AEC and industry.

U.S. ATOMIC ENERGY COMMISSION—AEC MANUAL

Volume 9000 Contracting. AEC 9113–01
Part 9100 Procurement and Contracts. CSSC

CHAPTER 9113 PATENTS AND COPYRIGHTS

9113–01 *Patents and Inventions.*

011 *Purpose and Scope of Section.* This section sets forth the policies and practices of the AEC in connection with patents and related matters and prescribes contract articles for the purpose of protecting the Government's interest by securing to the Government (a) patent rights in research and development contracts, operating and service contracts, architect-engineer contracts, special contracts and subcontracts and purchase orders thereunder and (b) protection against patent risks in architect-engineer, construction, and supply contracts and purchase orders.

012 *Rights in Inventions under Contracts.*

a. The current practice of the AEC as to provisions relating to inventions to be inserted in contracts and subcontracts (as defined in 9101–022e) is determined primarily by—

1. the character of the work to be performed under the contract; such as research or development; routine development; construction; supply; quantity production; and
2. the industrial and patent position of the contractor in the field of work of the contract.

Where provisions relating to inventions are appropriate, a provision concerning waiver of claims for pecuniary awards or just compensation under the Atomic Energy Acts shall be included. A similar provision shall be included in employee agreements. No provision pertaining to inventions need be used where ordinary commercial materials or equipment are to be furnished "off the shelf" or in ordinary construction contracts not involving special buildings or equipment. In such instances, however, an indemnity provision, as set forth in 9113–019 in favor of the Government shall be obtained.

b. Any question as to modification, interpretation, or application of the appropriate patent provisions shall be referred to the local AEC counsel for action in collaboration with the local Patent Group, or where no local Patent Group exists, with the Chief, Patent Branch, AEC, Washington.

* 013 *Type A Patent Provisions.* The following patent article shall be used when the work to be performed or the material or equipment to be furnished by the contractor is of such character that any inventions or discoveries that may be made probably will relate directly to or concern some phase of the research or development work which AEC conducts or sponsors.*

"TYPE A PATENT PROVISIONS

"1. Whenever any invention or discovery is made or conceived by the contractor or its employees in the course of, in connection with, or under the terms of this contract, the contractor shall furnish the Commision with complete information thereon; and the Commission shall have the sole power to determine whether or not and where a patent application shall be filed, and to determine the disposition of the title to and rights under any application or patent that may result. The judgment of the Commision on these matters shall be accepted as final; and the Contractor, for itself and for its employees, agrees that the inventor or inventors will execute all documents and do all things necesary or proper to carry out the judgment of the Commission.

"2. No claim for pecuniary award or compensation under the provisions of the Atomic Energy Acts of 1946 and 1954 shall be asserted by the contractor or its employees with respect to any invention or discovery made or conceived in the course of, in connection with, or under the terms of this contract.

"3. Except as otherwise authorized in writing by the Commission, the contractor will obtain patent agreements to effectuate the purposes of paragraphs 1 and 2 of this article from all persons who perform any part of the work under this contract, except such clerical and manual labor personnel as will not have access to technical data.

"4. Except as otherwise authorized in writing by the Commission, the contractor will insert in all subcontracts provisions making this article applicable to the subcontractor and its employees."

*Revised: June 20, 1955.

*014 *Type B Patent Provisions.* The following patent article shall be used when the work to be performed or material or equipment to be furnished by the contractor is of such character that any inventions or discoveries that may be made probably (a) will relate only incidentally (and not directly) to some phase of the basic research or development work which AEC conducts or sponsors, but (b) will relate to a field of work in which the contractor has an established industrial and patent position.*

BURNS & ROE, INC.,
New York, N.Y., February 19, 1960.

The Honorable CLINTON P. ANDERSON,
Congress of the United States,
Joint Committee on Atomic Energy,
Washington, D.C.

MY DEAR SENATOR ANDERSON: In reviewing the report sent to us by the Joint Committee on Atomic Energy on the civilian power reactor program study, we are somewhat concerned with what appears to us to be the principal emphasis of the report—namely, the very natural attempt to promote the development of a few proven or semi-proven types of reactors such as pressurized boiling water, organic cooled, gas cooled, and fast breeder. While we recognize fully that it would be unwise and funds certainly could not be made available for the exploration of all the potentials of the atomic field, it does seem to us that certain potentials need more support if from a long range viewpoint we are to get the best that is available from the development of atomic power.

Certain reactor types that in our minds have merit such as the heavy water and the aqueous homogeneous types seem to be reduced in effort either by virtue of joint participation or reduction in capital funds. Our feeling is that the aqueous homogeneous reactor program offers enough potential in the form of low fuel cycle costs that it might be well to do some further work on this in spite of the inherent difficulties of development which are, of course, recognized.

Also, we find no reference to direct conversion power generation or controlled fusion power generation. Direct conversion by thermionics or thermoelectric appears feasible with sufficient research since it would appear that the potential power economics are likely to be attractive.

We trust the above viewpoint may be of some interest to you.

Very truly yours,

R. C. ROE, *President.*

STATEMENT OF ALEXANDER GRENDON, COORDINATOR OF ATOMIC ENERGY DEVELOPMENT AND RADIATION PROTECTION, STATE OF CALIFORNIA

Upon the invitation of the chairman of the Joint Committee on Atomic Energy, the following statement is submitted for the record of the hearings to be held by that committee pursuant to section 202 of the Atomic Energy Act of 1954. The matters discussed are arranged in the order of the list of "Suggested Topics—1960" attached to letter of invitation, insofar as they can be related to those topics.

1. The siting of nuclear reactors has been surrounded with safeguards to minimize public hazard, yet the process leaves something to be desired from the viewpoint of those close to each site. By the time the State and the local groups are afforded opportunity to express their views as to the acceptability of a contemplated site, the economic commitments associated with the project are often great enough to offer strong resistance to any suggested change. We in California are trying to develop some explicit, firm criteria that may constitute a minimum standard to be met by any proposed site, even while recogniz ng that each proposal must be evaluated on its merits and that the established minima may be inadequate in any particular instance. It is felt that some precise specifications, however few, are better than none at all and may serve to forestall investment in a project that is certain to meet with objection. It would be of great aid to us if the AEC, in its consideration of safety criteria for reactor sites, as announced in its news release No. B–79, May 22, 1959, would seek to attach specific minimum (or, in some cases, maximum) numbers to factors involved in these criteria. "Several miles," "large reactors," "large

*Revised: June 20, 1955.

cities," "relatively impermeable," and other qualitative terms would be enhanced in usefulness if supplemented with numerical values or formulas constituting minimum requirements.

2. The Navy and maritime reactors pose a serious problem for coastal States, in particular. California's regional water pollution control boards have sought to obtain data to evaluate the local hazards involved in the presence of the Navy's nuclear-powered vessels in our harbors, but with only a negligible degree of success. BuShips Instruction 9890.5, dated May 12, 1958, establishes procedures and limits for radioactive waste disposal, though the limits set therein are based on outdated standards and on some assumptions that might well be challenged. BuDocks Instruction 11345.1A, dated December 3, 1958, establishes Navy policy regarding cooperation with local authorities in pollution abatement, but apparently has reference to shore stations only. In the latter regard, the practice has lagged far behind the principle in some of the naval installations in California, insofar as nonradioactive wastes are concerned, thus casting some doubt on how much concern may be displayed with regard to radioactive wastes. Taken together, the use of qeustionable standards for allowable discharge of radioactive wastes, a history of reluctance to cooperate in abating ordinary pollution, and an apparent unwillingness to disclose or discuss the data that might permit independent evaluation of the radioactivity hazard by local agencies give cause for concern as to the future trend in the use of nuclear power for ships. It is urged that a policy be established that will afford State and local agencies greater opportunity to gage the hazards in adjacent waters from the presence of nuclear-powered vessels and a more effective role in controlling them.

3. The industrial uses of radioisotopes, and the dispersal to the environment of radioactive wastes that often accompany these uses as well as reactor operations, are closely hinged to a set of standards of permissible exposure about which endless arguments have raged. It may well be that the consequences of exposure at very low levels of intensity, or to low values of total dose, have been materially overestimated, thus imposing unnecessary handicaps on industry, or underestimated, with undesirable risks to the public health. The basic problem is that proponents of both views can argue only from theory, since the only data available pertain to much higher doses than the established permissible limits. The theoretical model chosen to extend the observed effects to much lower doses determines the conclusion as to the significance of these doses. The lack of data in the region of interest stems from the fact that it would take an experiment with enormous numbers of subjects, under carefully controlled conditions, to prove or disprove the existence of an effect as small as might be expected, in terms of percentage of those exposed, when that effect is masked by the natural occurrence of similar events. An experiment of that kind would be very costly, but its value in affording a firm basis for evaluation of the risk in very low levels of exposure would be inestimable. Sponsorship of a carefully designed experiment on a sufficiently grand scale should be made a prime objective of the national atomic energy program.

CALIFORNIA RESEARCH CORP.,
RICHMOND LABORATORY,
Richmond, Calif., February 1, 1960.

Senator CLINTON P. ANDERSON,
Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR SENATOR ANDERSON: Thank you for your letter of January 20, inviting me to testify before the committee in this year's section 202 hearings.

Although I might be able to contribute some interesting information out of our company's experience in the industrial development and uses of radioisotopes, I do not believe anything I would have to say would be sufficiently new or different from what you have heard before to justify taking your time for it now.

We have actually encountered very few problems in our varied uses of isotopes in petroleum research and refining. We have found the personnel of the AEC Isotopes Division very cooperative in ironing out such problems as have existed.

We have been interested in sharing our experiences in the beneficial uses of isotopes with other industrial groups who are not yet taking advantage of this tool. It appears to me that constructive steps are now being taken to expand the uses of isotopes into these new areas. I particularly have in mind the courses that are being given at the Oak Ridge Institute of Nuclear Studies and that are being organized in university and even in high school extension divisions.

One step that I definitely believe would greatly aid the wider use of radioactive tracers is the final adoption of 10 CFR sections 30.8 and 30.73, pertaining to exempt concentrations of radioisotopes, published in the Federal Register, October 31, 1958 (23 FR8428). The logic in favor of this amendment is unassailable, and there are many demonstrated useful applications that will find much wider use as soon as it is adopted.

In the event that the committee should find it desirable at some future time to schedule hearings specifically on the subject of industrial use of radioisotopes, along the line of hearings that you have had in other specific fields, we would certainly be glad to take part. But at the moment, we do not see any problems in the industrial isotope field pressing enough to require oral presentation to your committee.

Respectfully yours,

D. E. HULL.

CAROLINAS VIRGINIA NUCLEAR POWER ASSOCIATES, INC.
Richmond, Va., February 4, 1960.

The Honorable CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR SENATOR ANDERSON: We appreciate the invitation of the Joint Committee to submit a statement in connection with the hearings to be held under section 202 of the Atomic Energy Act of 1954. Since our project is progressing satisfactorily according to schedule, the time of the committe can be saved by submission of our statement in writing.

Since the hearings under section 202 in 1959, CVNPA has concluded the necessary arrangements with South Carolina Electric & Gas Co. for the long-term lease of the reactor site and for the purchase from CVNPA by South Carolina of the steam produced by the nuclear plant for South Carolina's use in the generation of electricity at its adjacent steam-electric generating plant.

The necessary research and development work for the construction of this pressure tube reactor is being carried forward with the assistance of Westinghouse Electric Corp. (Westinghouse) under a contract dated June 17, 1959, that was executed with the approval of the AEC. Several problems have been encountered, but it appears that the research and development program affords assurance for their satisfactory resolution. After hearings on the CVNPA project on September 11, 1959, and December 11, 1959, the AEC's Advisory Committee on Reactor Safeguards concluded that "a reactor of this general type with containment as proposed by [CVNPA] for the Parr location may be constructed and operated at the site selected without undue risk to the health and safety of the public." During these hearings there was a thorough exposition of the major design characteristics and the research and development program. The advisory commitee was particularly interested in CVNPA's testing program for the suitability of zircaloy as a material for the pressure tubes. In the study of this program, we have had helpful cooperation from the Hanford Laboratory and from Atomic Energy of Canada, Ltd. The Hanford and Canadian reactors are the same general type as the CVNPA reactor, and the experience of the three projects should continue to be mutually beneficial. A critical experiment is scheduled to begin in April of this year at the Westinghouse Reactor Evaluation Center, and we expect that it will verify many of the conclusions indicated by our research and development work.

During the past year the administration of our contract with AEC was first assigned to the New York operations office and then transferred to the Savannah River operations office. Our relationship with both of these offices has been highly satisfactory and beneficial.

CVNPA has applied to the AEC for a construction permit and a public hearing has been set for February 23, 1960. If the permit is granted, CVNPA plans to begin construction at the site in the late spring. Plans for construction are

being matured by Stone & Webster Engineering Corp., CVNPA's construction supervisor, and Westinghouse. Meanwhile negotiations with Westinghouse on an apparatus supply agreement for material to be used in the reactor are in progress. This contract should be executed in the near future.

CVNPA has made arrangements with Lockheed Aircraft Corp. for consultation with expert meteorologists. With their assistance, CVNPA is conducting an intensive survey of weather at the reactor site. CVNPA is also engaged in a study of the mutual radioactivity of the area. In this study the South Carolina Water Pollution Authority has been most cooperative. Both of these studies will supply data that will help to assure the safe operation of the reactor.

Our experience to date on the CVNPA project has confirmed our expectations that the project is feasible, will be completed on schedule in 1962, and will be successful in advancing the art of generating electricity from atomic energy.

Yours respectfully,

E. H. WILL, *President.*

CHAMBER OF COMMERCE OF THE UNITED STATES OF AMERICA,
Washington, February 25, 1960.

The Honorable CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Senate Office Building, Washington, D.C.

DEAR SENATOR ANDERSON: The Chamber of Commerce of the United States 1960 legislative program in the field of atomic energy is attached. This is the statement I mentioned in my January 29, 1960 letter.

The statement was drafted by our committee on commercial uses of atomic energy and approved by the national chamber's board of directors on February 13, 1960.

The chamber is convinced that the principles set forth in the attached go a long way toward fulfilling the objective of the Atomic Energy Act of 1954 to "strengthen free competition in private enterprise."

I should like to stress several points in our program. Points 1, 2, and 3 are designed to increase private industry's role in the Government's atomic energy program. We applaud the Joint Committee on Atomic Energy and the Atomic Energy Commission for the many efforts to make greater use of existing and expanding industrial capacity and technical skills. Our sole purpose is to further the progress already made.

There seems to us to be a need for a clear, written statement of the Commission's policy on procurement from private facilities backed by specific instructions of implementation to all Government-owned atomic energy installations and an appropriate follow-up procedure. This, we would hope, could result in more uniform application of the Commission's policy which in turn will be of great help to a young industry trying to plan its future.

We do not wish the closure of Government laboratories, but rather the transferring out of the laboratories of work which can be done with reasonable efficiency in privately owned facilities so that the laboratories may concentrate on their proper and all-important function of frontier research.

Point 4 of the attached program summarizes a longstanding chamber policy on atomic electric power which reads in part as follows:

"The Federal Government should not own or operate atomic powerplants for commercial energy production. Aside from regulation, Government activity in the area of atomic power generation should be limited to research, development, experimentation, and the encouragement of wide industrial participation. As soon as the stated purpose of any Government experimental facility has been achieved, it should be disposed of. Should any Government experimental facility have a residual economically feasible use, it should be offered for sale. The production for sale to the public electricity generated by means of atomic power should be the responsibility of the existing utility industry. Any interim production of atomic energy by experimental facilities at Federal Government atomic energy installations should either be used by the Government in the operation of such installations or disposed of on a nonexclusive basis to distributing utilities in the area without preference or discrimination."

To assure maximum utilization of individual creative ability, normal patent rights (as established by the patent statutes of the United States) should be applied to all inventions relating to atomic energy. Normal patent rights should be applied regardless of whether the inventions were a result of Government

contracts and subject only to a royalty-free, nonexclusive license for Government use of patents developed as a result of Government contracts.

Pending restoration of normal patent rights (point 6 of the attached program) American industry should be permitted to obtain adequate patent protection in foreign countries. For this purpose, Government contractual relationships should permit private contractors to take the initiative in establishing appropriate foreign patent rights in their inventions.

We appreciate this opportunity to explain the national chamber's views on what is needed to encourage the development, growth, and state of the atomic energy industry and would like this letter and the attached statement included in the record of the Joint Committeee's section 202 hearings.

Cordially yours,

CLARENCE R. MILES,
Manager, Legislative Department.

THE 1960 LEGISLATIVE PROGRAM IN THE FIELD OF ATOMIC ENERGY

Congress should enact legislation in the atomic field which, while implementing both domestic and international objectives, does so by strengthening our domestic enterprise system.

Specifically in dealing with atomic energy legislation Congress should incorporate the following principles:

1. Enact policies and programs designed to make maximum use of the Nation's free enterprise system.
2. Eliminate Government competition with private industry.
3. Examine and define the role of Government-owned installations with specific attention to effecting transfer of functions to privately owned installations wherever feasible as intended by the Atomic Energy Act of 1954.
4. Make certain that the Federal Government does not own or operate atomic powerplants or other facilities for commercial purposes.
5. Insist that the Government make public all information as to the full financial assistance provided for any commercial atomic program in which it participates.
6. Restore normal patent rights in the field of atomic energy.
7. Eliminate unnecessary secrecy which hampers the development of private industry in the atomic energy field.

(The following letter is also included as part of the Chamber of Commerce statement:)

BIG CHIEF DRILLING CO.,
Oklahoma City, Okla., February 3, 1960.

Mr. JOHN A. MCCONE,
Chairman, U.S. Atomic Energy Commission,
Washington, D.C.

DEAR MR. MCCONE: On behalf of the Chamber of Commerce of the United States and its committee on commercial uses of atomic energy, I express our appreciation for the opportunity to meet with you and the members of your staff on January 27. In addition, I would like to express my personal gratitude for your kind consideration in meeting with Mr. Lederman and me on January 20.

It seemed to me that our meeting on January 29 was useful in that it served to clarify the committee's view and the Commission's attitude and philosophy on the proper roles of Government-owned installations and private facilities in the atomic energy program.

I would like to summarize key points which were discussed:

1. The U.S. Chamber of Commerce does not wish the closure of Government laboratories but rather urges the transfer out of the laboratories of work which can be done with reasonable efficiency in privately owned facilities so that the laboratories may concentrate on their proper and all-important function of frontier research.

2. There seems to us to be a need for a clear, written statement of the Commission's policy in this area backed by specific instructions of implementation to all Government atomic energy installations and an appropriate followup. This we would hope could result in more uniform application of the Commission's policy which in turn will be of great help to a young industry trying to plan its future. We look forward to receiving a copy of the staff report you

mentioned in the course of our conversation which will review accomplishments up to date.

3. Your invitation to set up a task force of our committee on commercial uses of atomic energy to spell out our suggestions along these lines is appreciated. We are currently forming such a group.

We applaud the AEC for its many efforts to make greater use of existing industrial capacity and technical skills. Our sole purpose is to aid the Commission and industry generally to further the progress already made.

Thank you again for the opportunity to meet with you. We look forward to continued friendly and constructive relations between the Commission and the chamber.

Sincerely yours,

JACK H. ABERNATHY,
Chairman, Committee on Commercial Uses of Atomic Energy,
Chamber of Commerce of the United States.

CITIES SERVICE OIL CO.,
New York, N.Y., February 13, 1959.

Hon. CLINTON P. ANDERSON,
The U.S. Senate,
Washington, D.C.

DEAR SIR: This will acknowledge your letter of January 27, inviting me to testify before the Joint Committee on Atomic Energy. The only subject listed on page 2 of your letter on which I feel qualified to comment is item (3), namely, the Government's program for nuclear maritime propulsion. As I shall be in Europe on the dates you mention for the hearings, I thought it best to reply to you by letter.

Over the past 3 years, we at Cities Service have been making a thorough study of the possibility of using atomic energy as a fuel aboard large tankers. In our studies, we have collaborated with many companies who are engaged in studying the atomic energy program and/or supplying hardware for the industry.

The operation of submarines with atomic power by the Navy has proved the feasibility of using the medium for propulsion of ships. In the case of the Navy, the ability to perform feats which would be impossible using conventional fuels amply justifies the extra cost incurred. We heartily agree that the Navy is to be highly congratulated on their success in these matters.

However, in the case of a surface ship carrying petroleum or dry cargo, no one has as yet envisioned using the medium to accomplish anything except to replace the present conventional methods of propulsion using fuel oil or diesel oil for fuel. We do not see how the use of atomic energy would be a superior method of doing this; therefore, if it is to be attractive to a shipowner, it must be a cheaper way of doing it.

While the *Savannah* will amply demonstrate the feasibility of using atomic power as a propulsion medium for a ship, the next step in the program is to develop a vessel which will do this competitively. We believe that once a competitive or nearly competitive system has been devised, industry can and will carry the ball from there on.

However, the cost of performing research and development work in the atomic energy field is so large that, in our opinion, only the Government can provide the funds necessary to keep the state of the art in the United States ahead of, or at least on the same level, as our foreign competitors. In these countries, of course, the government supplies the bulk of the necessary funds. It seems to us that if the proper funds and individuals are assigned to this ship project, it will be possible to realize our goals.

We are of the opinion that over the near term period the major effort as far as a ship reactor is concerned should be expended in trying to develop a competitive or nearly competitive system. This will eventually lead to the construction of a vessel by the Government to demonstrate the feasibility of the system developed.

In conclusion, therefore, we are of the opinion that only if our Government will bear the cost of the necessary research and development along the lines outlined above, will it be possible to develop a suitable reactor for competitive surface ship operation in this country.

Very truly yours,

E. G. MADDOCK.

COMMONWEALTH ASSOCIATES, INC.,
Jackson, Mich., February 11, 1960.

The Honorable CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

MY DEAR MR. ANDERSON: Your letter of January 20 inviting our testimony before the Joint Committee on its section 202 hearing is very much appreciated.

Engineers of our Commonwealth Associates, Inc., organization have been actively engaged in the nuclear power program since 1954. At the present time, we are completing the detailed engineering designs for the Enrico Fermi Atomic Power Plant at Lagoona, Mich., and for certain thermonuclear research facilities of the James Forrestal Research Center at Princeton, N.J.

We feel that the nuclear power program should include some provision for further development and experience of the many engineers, scientists, and technicians who have acquired much knowledge and experience under present programs. Their efforts should continue in this field to forestall loss of their talents and any consequent slowing down a few years hence of the program for development of economic nuclear power.

A new technological field has been created as a result of AEC's invitations to the power industry to participate in research and development of nuclear power. A large corps of people having management, engineering, and craftsmanship skills unknown in prior decades has been organized and trained. This valuable group of knowledgeable people will need to maintain and further develop their techniques and skills if the technical gains of the 1950's are to continue on during the 1960's. Without a progressive program these personnel will rapidly disseminate into other fields of endeavor and their nuclear skills and techniques may be lost because of their inactivity in the nuclear power field.

There appears to be a tendency at this time to wait for operating experience on plants now in operation or nearing completion before proceeding with the development of a new group of plants to extend the technological development of nuclear power. While the practice of digesting one stage of development is indicated in some areas of engineering design, it should be recognized that advancements of the art have already occurred in the research, design, and construction of plants now underway or recently completed, even though some characteristics, capabilities, and limitations cannot be fully explored until an extensive program of testing and operation has been completed. For the next program of design, construction, and operation of large plants, significant departures from limitations imposed during design of the first demonstration units seem to us to be justified even before some of these plants are in operation. Such departures should result in considerable reduction in plant investment per unit of power capability and in fuel-cycle costs per unit of power generated. To illustrate this point, it is only necessary to observe the new interest in nuclear superheating for water and organic moderated reactors and the considerations being given toward increasing the power density and extending the fuel life of newer plants beyond those of earlier designs. Operating present units within their design limitations may not help sufficiently to obtain all the data needed concerning many possible engineering advancements but, nevertheless, will serve to train new groups of people in operation and maintenance skills and, through the sale of kilowatt-hours, will provide a partial return of money invested in the demonstration program.

To await considerable operating experience before undertaking engineering design advances does not appear to be profitable because of the large potential future savings of nuclear power through utilization of advanced technology already evident. Most observers would agree that in the high fuel cost areas of the United States which need large blocks of power, savings of as much as 1 mill per kilowatt-hour should be possible with nuclear heat sources within a decade if design and operational development proceeds in an aggressive and orderly fashion.

It would seem reasonable to expect that by the end of this new decade the Nation's energy requirements will again have increased to something in the order of double that now required. The constantly rising costs of fossil fuels make the potential savings through the generation of only 5 to 10 percent of the huge energy requirements of the 1970's by nuclear powerplants very substantial indeed. Such an expected savings in dollar costs of power generation at that time would seem to justify a substantial expenditure for additional

full-scale developmental plants during the next 10 years to achieve so desirable a goal for the succeeding decade.

We conclude that notwithstanding certain present uneconomic aspects of nuclear power, design advancements should continue at full speed in benefits of such savings are to be realized at the earliest possible time. At the same time, and the skills of the engineers, scientists, and craftsmen necessary for such a program must be developed rapidly if such a desirable program is to be carried out on an optimum schedule.

We venture to offer a few comments on the economics of certain nuclear power reactor types that are much in the limelight today. Recent research studies indicate that the slightly enriched water-moderated and the organic-moderated reactors may be desirable for development in the immediate future, and we concur with such thinking. However, our experience with the design of the liquid-cooled fast neutron reactor indicates that this type of reactor probably should be receiving greater attention. The expressions from a number of sources indicating that this reactor is of interest only for the distant future do not seem to be entirely realistic. In our opinion, the economic potential of the liquid metal-cooled fast neutron reactor is good indeed. This potential stems from some very fundamental engineering concepts being developed at this time as follows:

1. A potential of long fuel life many times greater than that of the slightly enriched moderated reactor appears to be possible and may be unique to the fast neutron reactor. Fuel cycle costs of something less than 2 mills per kilowatt-hour should be obtainable with this reactor through continuing development and testing during this decade.

2. It is now evident that irradiated fuel need not be removed from a fast neutron reactor to cool down before shipment to a processing facility. The spent fuel can be decayed in the outer edges of the core blanket and then shipped directly to fuel-processing facilities. This would greatly reduce the required fuel-handling facilities and would effect substantial reductions in plant costs.

3. The small physical size of the fast neutron reactor and the heat-transfer efficiency of liquid metals used in such reactors should permit use of much smaller amounts of shielding and lower volume containment buildings with consequent large reductions in investment for such facilities.

The considerations and factors recited above have led us to the conviction that the fuel costs of such plants are potentially less than fossil-fuel costs in many areas, and that eventually plant investment costs should not be substantially greater than for fossil-fueled plants. It is our opinion that this goal may be achieved by 1970 or even before that year if additional full-scale designs should be undertaken promptly and construction and testing programs proceed without delay.

It appears to us that the goal of economic nuclear power is now rapidly coming within the reach of technical feasibility. However, concerted action must be maintained for such achievement through the continuing efforts of engineers, scientists, and technicians working in the nuclear power field, together with the uninterrupted development of engineering designs and the fabrication and testing of equipment associated with nuclear plants embodying advanced designs.

Yours very truly,

J. H. FOOTE, *Chief Engineer.*

CONSOLIDATED EDISON CO. OF NEW YORK, INC.,
New York, N.Y., February 23, 1960.

HON. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Washington, D.C.

DEAR MR. CHAIRMAN: This letter is submitted on behalf of Consolidated Edison for inclusion in the record of the "Section 202" hearings being held by your committee.

In the notice of the hearings you listed a number of topics to receive special attention by the committee. The only one of these subjects of specific interest to my company is that of the so-called 10-year program. This plan was first outlined by Dr. Frank Pittman at the November 1959 meeting of the Atomic Industrial Forum. In general, the plan, as I understand it, provides a reasonable framework for concentrating on certain reactor types which show promise of

achieving economic power in a relatively short time. While imagination in basic research must still be encouraged, it becomes more and more evident that economic power from the atom will be achieved only by painstaking engineering effort rather than by some magical breakthrough or by a scattered expenditure of money and talent.

In the case of our own Indian Point plant, to be located in Westchester County, N.Y., the complexities of design now appear to be solved. Last year, we mentioned to you the change in the composition of the reactor core. The thermal, nuclear, and mechanical design of the core is now completed and the final design is reflected in recent material filed with the Atomic Energy Commission. Inherent in this design are certain characteristics which we and the Babcock & Wilcox Co., which is to manufacture the core, believe represent a substantial contribution to nuclear technology. We have held firmly to our objective of both long reactor core life and high power capability. The expected good performance of the core results primarily from the use of thorium as a fertile material and from the improvement of the power distribution by loading the fuel in a carefully selected pattern over the core. We hope that even better performance can be obtained from future cores, with resulting reduction in operating costs.

Work at the site has proceeded without interruption since our last report to the committee. The accelerating rate of field construction is evidenced by the fact that over $13 million was expended during the last 3 months of 1959 for plant equipment and field installation. The reactor containment vessel has been pressure-tested and the external biological shield completed. The erection of foundations for the reactor vessel is substantially completed and construction of buildings for fuel handling and for waste treatment is underway. The oil-fired superheaters have been erected and parts for the main turbogenerator are being delivered.

Functional design of all reactor systems and components has now been completed. First steps in the manufacture of the first core have been taken. By the middle of May it is expected that all four steam generators, the pressurizer, and the reactor vessel will have been received at the plant site. Most research and development work has now been finished but some testing work on fuel materials, fuel cladding, and sample fuel elements will be continued through 1960 and part of 1961.

At the start of 1960 the total expenditures on the plant totaled about $50,300,000 for equipment and field construction, and slightly over $10 million for research and development. Our estimate of total capital costs remain unchanged from those supplied to the committee last year. We expect the plant to be in operation by September 1961. This is somewhat later than we had hoped because of a delay of several months in the delivery of important nuclear equipment.

As a concrete result of our progress, the Atomic Energy Commission, acting upon a recommendation of the Advisory Committee on Reactor Safeguards, generally approved last July the "unusually thorough containment" for the reactor at the Indian Point plant. In January of this year we submitted to the Commission a comprehensive hazards summary report which we hope can be considered by the Commission and the Safeguards Committee in the near future.

An outline of operating instructions for the plant has been prepared. Representatives of Consolidated Edison have had numerous discussions with members of the Commission staff regarding training of personnel. Based upon the experience of the Commission as well as other factors, it was agreed that the best possible experience available for the operators of our reactor would be to make them a part of actual operating crews. The MTR and ETR reactors at ARCO seemed best suited for this training since their operations involve numerous startups, shutdowns, and scrams. Eight of our men have already completed 6 months' training at ARCO and ten are presently there. Three prospective operators have taken training at Shippingport. Others will go to Shippingport after their other training.

All our health physicists, maintenance crews, and chemists have either attended an extended course at Shippingport or have studied elsewhere.

Then men who will be the general superintendent and the assistant general superintendent of the plant have both spent 6 weeks in observing and participating in operations at the General Electric Vallecitos boiling water reactor. They will also be trained at Shippingport.

We are, of course, still concerned with the costs and methods of reprocessing material after its use in our plant. In partnership with four other companies we

have made a study contract with Davison Chemical Co. to examine the technical and economic feasibility of constructing a private facility to reprocess spent nuclear fuels. We are also considering making arrangements to have an outside concern handle the transportation of the spent fuel from our plant to a reprocessing site. The effort to date by the utility and equipment manufacturing segments of industry must at some point be paralleled by efforts by the chemical industry to solve the serious problems of waste disposal.

From the long-term standpoint we believe that the public has much to gain from our endeavor. As the urbanization of the United States continues, it will become increasingly advantageous for a powerplant to be placed safely close to the load it serves without polluting the air. Atomic powerplants can surely satisfy this requirement.

Respectfully yours,

J. F. FAIRMAN,
Senior Vice President.

STATEMENT BY R. L. SCHACHT, GENERAL MANAGER OF CONSUMERS PUBLIC POWER DISTRICT

I am pleased to have the opportunity to, once again, review the participation of Consumers Public Power District in the Commission's power reactor demonstration program. As you know, our activities are centered on the construction and operation of a sodium graphite reactor at the Hallam nuclear power facility. This program was reviewed with you in our last communication to the Subcommittee on Legislation of the Joint Committee on March 11, 1959. Inasmuch as the background of our organization and our progress up to March of 1959 is a matter of record of this committee, I will confine my statement to the progress which has been made since that time.

Under the terms of our contract with AEC, we are to provide an operable turbine generator and the associated conventional equipment required for power production, using steam produced by the nuclear facility. In this program Consumers district has the reactor operating responsibility rather than to simply purchase steam from a reactor owned by and operated for the Commission.

CONVENTIONAL EQUIPMENT

Major on-site construction work on the conventional equipment started in April 1959 with the installation of the rail siding and other site-supporting activities. At the present time, the substructure concrete and underground piping have been completed. The structural steel erection is 95 percent complete and the major portion of the conventional building siding is in place. Early closure of the building has permitted a continuous construction effort during the winter months. The turbine generator equipment is in the building and being placed. A conventional boiler is being installed by Consumers so that it may be used to provide a firm power supply prior to completion of the reactor and during test operation of the reactor. Construction of the boiler is also in progress.

All major equipment is on order and the general mechanical and the general electrical contracts have been let and their forces are on the site.

Construction of the conventional facilities continues to progress on schedule with the only contract yet to be let being the painting contract. The conventional facility contracts represent a commitment of approximately $22 million for this portion of the plant being supplied by Consumers. These conventional facilities will be ready for operation in April of 1961.

REACTOR EQUIPMENT

Consumers has also committed slightly more than $4,500,000 for the construction of certain nuclear facilities which represents 27 percent of all funds committed up to January 1, 1960, for the nuclear facility construction.

At the present time the reactor substructures are essentially complete and the internal concrete walls and shielding is being placed. The majority of structural steel has been erected and the reactor building siding installation was started within the last few days.

Atomics International has the overall technical responsibility for the reactor and are conducting the research and development necessary to provide the basic

information being used in the Hallam engineering and design. Problems associated with the design of this developmental equipment as well as in the design of the graphite moderator cans and fuel elements points to the necessity of maintaining an active Commission program of sodium component development. Atomics International is also procuring certain key pieces of equipment for the reactor installations, particularly that equipment which makes up the core of the reactor and the associated control systems.

Atomics International has also prepared a reactor hazards report for consideration of the Advisory Committee on Reactor Safeguards. Supplements to the original report are being provided to that committee as rapidly as design information is available. There appears to be no major difficulty in this phase of the program.

The Bechtel Corp., as another prime contractor to the AEC, is providing the architect-engineering and inspection services for the HNPF. Peter Kiewit Sons, Inc., as still another prime contractor to the AEC, is providing the on-site construction management for the program.

That portion of the reactor construction being carried out by the Commission is scheduled for completion in time to start criticality tests in late 1961 and full power operation by mid-1962. The Commission has the responsibility for the reactor construction and we assume that the AEC wil provide the reactor status report. Meeting the scheduled completion dates may well hinge on the selection and effective management of qualified general mechanical and general electrical contractors. The selection of these two contractors will be made in the near future.

OPERATING PERSONNEL TRAINING

Key personnel of the operating staff have been employed by Consumers and a reactor operations training program was started in January of this year. This training program will consist of 9 weeks of training in Nebraska followed by 14 to 20 weeks of training in Los Angeles at Atomics International. The study program in California will be devoted to on-the-the job training on the sodium reactor experiment and certain other sodium test equipment operated by Atomics International.

Two additional groups of personnel will be added to the staff within the next few months and a similar program of training has been adopted for these operators. The total personnel compliment will consist of 62 men.

INSURANCE

In our contract with the Commission, the Government indemnifies Consumers District against nuclear hazards during the operation of the plant. As a result, it has not been necessary for Consumers to obtain any nuclear hazard insurance from the private insurance industry. One unexpected development has arisen in obtaining conventional plant insurance. As the construction progressed we obtained the normal coverage of builders' risk from private insurance carriers. The amount of this kind of insurance was then increased as the construction progressed and the insurable values continued to increase. We have recently been advised that even though there are no nuclear hazards involved in such coverage either during construction or operation, standard insurance will no longer be available to us through our usual insurance carriers. Instead, this insurance must now be written through the Nuclear Energy Property Insurance Association which has been formed as a pool for underwriting nuclear hazards. Preliminary discussions with NEPIA have indicated that this coverage will be written without a premium penalty as compared with normal insurance underwriters. If this is actually the case, we favor this kind of relationship with NEPIA inasmuch as through it we will benefit by their experience and, in turn, they will be able to become familiar with the sodium reactor technology.

As of this time we have not explored this same situation in the field of liability coverages for the conventional plant operation. Since public liability insurance now specifically includes all nuclear risks, we do not anticipate any difficulty in this regard.

AEC RELATIONSHIP

In carrying out this joint construction and operation effort, there have been instances of differences of opinion between Consumers District and the Commission staff as to the responsibilities and methods of operation of the participants. These differences are undoubtedly common to any project of this magnitude. In every case, the Commission staff has been willing to discuss these problems and

dispatch them as promptly as possible. With continued cooperation by the Commission, we believe our contracting arrangement provides an acceptable method of participation in the power reactor demonstration program.

STATEMENT OF D. C. BRUNTON, PH. D., MANAGER, NUCLEAR RADIATION DEPARTMENT, CURTISS-WRIGHT CORP.

THE NEED FOR COBALT 60 RADIATION FACILITIES

As manager of the nuclear radiation department for the Curtiss-Wright Corp., I am concerned with building a business operation based on the application of large-scale use of nuclear radiation. We are not manufacturers of either radioactive sources or electron beam machines. We are suppliers of radioactive source handling equipment and services and design engineers for radiation applications, radiation shielding, and radiation cells.

I am concerned with the lack of adequate experimental radiation facilities throughout the country which will permit an aggressive attack on radiation applications for food preservation, for medical supplies sterilization, and for the development of new products through radiation chemistry. To be more specific, I am particularly concerned with the lack of adequate cobalt 60 radiation facilities. I have noted with alarm the assertions by electron beam machine manufacturers (refer in particular to the letters to Nucleonics magazine in their issues of June and September 1959) of the superiority of electron machines and of their alleged more favorable economics.

Let me attempt to set the record straight by presenting a technical comparison between machines and isotopes.

The most important factor in any comparison of isotopic and machine produced radiation is to realize that the two differ substantially and in most applications are not readily interchangeable.

Machines produce beams of electrons and cobalt 60 produces gamma rays. The gamma rays are very penetrating and may be used on material many inches thick. Electrons are not penetrating radiation unless of very high energy. They are limited to a little over one-tenth of 1 inch peneration per million volts of machine energy.

Electron beam radiations of relatively low energy (a few million electron volts are and likely will continue to be a cheaper form of radiation than gamma rays from cobalt 60. As such, they are ideal for irradiation of material in the form of thin films. They are not suitable, however, for bulk or packaged material irradiation. As the machine energy is increased to 20 or 25 million volts, an electron beam attains a penetration equivalent to cobalt 60 gamma rays. This increase in energy brings with it, however, certain disadvantages:

1. Induced radioactivity.
2. Increased cost.
3. Increased radiation shielding problems.

Although the theoretical threshold for production of induced radioactivity by electrons or gamma rays occurs at an energy of 2.2 million volts, no appreciable induced activity appears below about 5 million volts. Furthermore, it should be noted that most of these induced activities are quite short lived and will disappear if the product is allowed to stand for a reasonable period of time before consumption. However, under the present food and drug laws, in particular, according to the Delaney food amendment, radioactivity is considered carcinogenic and no induced radioactivity is permissible in any food product. This may well be interpreted to mean no measurable amounts of induced activity will be allowed and in such a case, electron machines below 5 million electron volts may be permitted as sources of radiation. But under the present law no electron beam machines will be permitted above approximately 5 million volts. Even should the food additive law be amended, high-energy machines face the major psychological barrier in that they must prove to the consumer that although they will induce radioactivity in the food, they will not do so to a harmful degree.

The second important disadvantage of high voltage electron machines is that they no longer assure low-cost energy production. The electron beam machine becomes a much more complicated product when it is required to operate around 20 million volts than it is at 2 million volts. This kind of machine is no longer a cheaper producer of radiation than cobalt 60 and there is no clear indication that it will become a cheaper producer of radiation in the future.

The third disadvantage of increasing energy of electron beam machines is the shielding problem. Although the electron beam is in itself essentially low penetration radiation, the electrons when striking any material will generate secondary X-rays which in turn are penetrating radiation. With most shielding materials, particularly with concrete, the penetrating ability of this radiation reaches a maximum in the range 5 to 10 million volts and consequently a 20-million-volt machine will produce a broad X-ray spectrum including substantial emission in the 5- to 10-million-volt region. Consequently the radiation safety shielding problem of such an installation is more severe than that with cobalt 60.

The fact that a percentage of high-speed electrons are converted to gamma rays when the electron beam strikes material has led to repeated suggestions that electron beam machines be used as X-ray or gamma ray generators. This principle is in fact used in betatron machines, used as very high energy X-ray machines for industrial radiography purposes. These machines use energies of 30 to 50 million volts. Such high energies are, in fact, less penetrating than 5- to 10-million-volt X-rays as indicated above, but the high energies are used to attain a reasonable efficiency of conversion from electron beam to X-ray beam. When considered for radiation processing work, however, this technique is not attractive. The low energy electron beam machines which can provide low cost radiation energy in the form of electrons have very low efficiency, only a few percent in conversion from the electron beam to X-rays, and consequently, as an X-ray generator these machines are considerably more costly radiation sources than cobalt 60. If one increases the energy high enough for efficient conversion, one already has a penetrating beam as an electron beam alone and all the attendant problems outlined above.

Cost comparisons between electron machines and isotope sources can be most misleading. The most important figure is the overall operating cost per unit of production. Frequently capital costs, which often favor electron machines, are the only figures given. The actual processing costs may tell an entirely different story. Industries interested in process radiation choose the radiation source best suited to their needs. Although the first commercial sterilizing unit in operation anywhere in the world is an electron beam machine, the first sterilizing installation requiring really penetrating radiation uses cobalt 60. The former is by Ethicon Corp. of New Jersey and the materials irradiated are sutures in relatively thin packages while the latter is by Westminster Carpets of Melbourne, Australia, and is used to destroy anthrax in bulk material. Also it is worthwhile noting that pharmaceutical products sterilized with cobalt 60 radiation are currently marketed in the United Kingdom by Wm. Warne & Co.

In my opinion, cobalt 60 is the ideal source for process radiation installations. It is simple and foolproof, it cannot fail and does not require high-priced technical talent to maintain in operation. These factors are important in any such installation. They are particularly important in considering process radiation installations in establishments which are themselves not primarily atomic energy centers, or electronic research centers.

Unfortunately, the existing cobalt 60 facilities in this country are very limited and for the most part, are small sources suitable for fundamental research problems on small samples. There are no adequate facilities which will provide a reasonable basis for demonstration and experimental testing of radiation processing. There are no adequate cobalt 60 facilities for implementation of an experimental food program which could process experimental or pilot plant quantities of food under the very conditions that such experiments will demand. I respectfully recommend that the Joint Committee on Atomic Energy encourage the provision of adequate cobalt 60 facilities for a vigorous program of radiation process development. This will require certain fixed cobalt 60 research irradiation at selected site and mobile units capable of experimental radiation processing on a variety of products at different locations.

STATEMENT SUBMITTED BY CHARLES R. LANDRIGAN, EXECUTIVE VICE PRESIDENT, THE DETROIT EDISON CO.

The Detroit Edison Co., a New York corporation, has as its principal business the supply of electric power to approximately 1,250,000 customers residing in 7,600 square miles of southeastern Michigan. The company's sales to those cutsomers during the calendar year 1959 totaled 13.2 billion kilowatt-hours.

The company is pleased to submit this statement concerning the nonnuclear facilities of the Enrico Fermi Atomic Power Plant for inclusion in the records of the hearings conducted during February 1960 by the Joint Committee on Atomic Energy in accordance with section 202 of the Atomic Energy Act of 1954.

The nuclear facilities of this plant, as reported in previous hearings, are being built and will be owned and operated by Power Reactor Development Co. (PRDC), and a separate report concerning that part of the plant is being submitted by that company. In accordance with agreements between the Detroit Edison Co. and PRDC, Detroit Edison is building and will own and operate the conventional steam turbine generator facilities adjacent to the nuclear reactor. Edison will purchase from PRDC the steam produced by the nuclear facilities, will utilize the steam in its turbine generator for the production of electric power, and will distribute the power in its existing power system.

In accordance with the company's longstanding practice of performing its own engineering and design services, Detroit Edison is doing the engineering and detailed design of the Fermi plant nonnuclear facilities. The design work is essentially complete, orders for all equipment have been placed with appropriate vendors, and all major contracts for construction of buildings and the erection of equipment have been negotiated.

Construction of the Detroit Edison Co.'s portion of the plant has been underway at the site since August 1956. The construction schedule for the Edison-owned nonnuclear facilities is carefully coordinated with the PRDC schedule for the nuclear facilities. It is now expected that construction of both the nuclear and nonnuclear sections of the plant will be essentially complete by the end of September 1960. Actual nuclear operation of the reactor is dependent upon the procurement by PRDC of a license to operate.

SITE AND SITE DEVELOPMENT

Last year we reported that site development was essentially complete except for (1) the condensing water intake canal and (2) cleanup operations after construction work is completed. The condensing water canal and intake structure are now complete except for the installation of the circulating pump. Cleanup and grading will be done during the latter part of 1960.

BUILDINGS AND EQUIPMENT

The steam turbine generator building is essentially complete except for finished floors and the closure of a section of the siding required to permit the installation of the condenser tubes.

A large part of the piping and mechanical and electrical equipment is now at the site and is being installed. The remaining equipment is scheduled for delivery to the site in accordance with the planned construction schedule.

The steam turbine-generator, with a gross capacity of 156,000 kilowatts of electricity, is being manufactured by the Allis-Chalmers Manufacturing Co. of Milwaukee, Wis. The generating unit is scheduled for delivery to the site in May and June. An erection schedule is now being developed to provide for completion by September 30.

As reported in previous hearings, the initial rated capacity of the Fermi plant is 100,000 kilowatts of electricity. The larger turbine generator was selected to accommodate a possible increase in overall reactor capacity as experience is gained.

SWITCHING STATION AND TRANSMISSION LINES

The 120-kilovolt switching station at the plant site is 75 percent complete and the two 120-kilovolt transmission lines to our existing power system have been built. One of these transmission lines and the switching station have been energized at 24 kilovolts and are being used to supply power for construction and nonnuclear test purposes.

COST OF NONNUCLEAR FACILITIES

We reported last year that the estimated cost of the nonnuclear facilities for the Fermi plant was $17 million. With essentially all equipment and materials now purchased, and all construction and erection contracts negotiated on a fixed price basis, the estimated cost remains unchanged at $17 million.

ATOMIC INFORMATION PROGRAM

Last year we reported that our company was engaged in extensive informational and educational programs to improve public understanding of atomic energy and to encourage young people to enter this field. In the 12 months from February 1, 1959, through January 31, 1960, more than 30,000 people visited the Enrico Fermi Atomic Powerplant site and were received at our atomic information center.

Qualified speakers, representing our company, addressed approximately 150 meetings of technical societies, schools, churches, service clubs, neighborhood groups, and others.

It is gratifying to us to have the broad public interest in atomic energy remain high. We believe we are successfully meeting that interest.

EMPIRE STATE UTILITIES POWER RESOURCES ASSOCIATES,
February 1, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy, Room F-88, Capitol Building, Washington, D.C.

DEAR MR. RAMEY: I am sending you herewith six copies of a press release that was made recently in connection with the establishment of the Empire State Utilities Power Resources Associates (ESUPRA) by the seven major electric utilities of the State of New York. We think this information should be of interest to the members of the Joint Committee, and perhaps you may wish to incorporate this information in the record of the 202 hearings.

If there is any further information you would like to have regarding ESUPRA, I would be very glad to supply it.

Sincerely yours,

ALEXANDER M. BEEBEE, *Executive Director.*

NEW YORK STATE UTILITIES FORM POWER RESOURCES GROUP—TO COMPLETE STATE POWER POOL GRID SYSTEM AND TO DEVELOP AN ATOMIC POWER PROGRAM

Realizing that future progress in New York State demands reliable and plentiful power at the lowest possible cost for all who want it, the principal electrical companies, who serve substantially all of New York State, and whose future depends on that progress, have formed an organization to broaden and strengthen their efforts in that direction.

The principal objectives of the new group is to develop a sound atomic power program, and to integrate and strengthen the existing power pool facilities throughout the State. The group is called Empire State Utilities Power Resources Associates (ESUPRA), with each of the chief officers of the participating companies as members.

The seven companies involved, and the members of the executive committee of ESUPRA are Charles Eble, of Consolidated Edison of New York; Earle Machold, of Niagara Mohawk Power Corp.; Joseph Bell, of New York State Electric & Gas Corp.; R. E. Ginna, of Rochester Gas & Electric Corp.; E. W. Doebler, of Long Island Lighting Co.; Ernest Acker, of Central Hudson Gas & Electric Corp.; and Charles Bulswit, of the Orange & Rockland Utilities, Inc. Alexander M. Beebee, former president and chairman of the board of Rochester Gas & Electric Corp., has been appointed executive director.

The utilities of New York State realize that to achieve maximum efficiency under modern conditions new concepts may be justified. The economy of recently designed very large plants, the advances in electrical transmission and new forms of generating power (including atomic power) are all factors that must ge carefully analyzed if the maximum of economy is to result.

Two primary tasks are planned, each to be handled by a trained staff of experts. One group will study and analyze the recent developments in atomic power with the objective of finding a method of generating power from nuclear fuels that will enable a saving to be passed on to our consumers. The other group will concentrate on the cheapest and most economical means of generating power in large plants with maximum efficiency at strategic locations and also will attack the problem of coordinating the generating and transmitting facilities of the State and neighboring States into a huge power-pool grid, in order to transmit that power to all the people of the area in the most efficient manner.

Chairman of the power grid program is Howard Harrington, of the Niagara Mohawk System at Syracuse.

Chairman of the atomic power study is Dean of Engineering John R. Dunning, of Columbia University, who is a man of great experience in nuclear matters, and a recognized authority on the subject. He will be assisted by Sidney M. Stoller as vice chairman, formerly vice president of Vitro Corp. of America. The technical staffs of the seven participating companies will be used to expedite the work.

The ESUPRA group stated that they realize that while electric power from atomic plants in this area at the present time is not economically feasible and would not provide any benefits that could be passed on to the consumer; nevertheless, they feel that progress in the art is so rapid that undoubtedly it may soon become a means for generating power that will enable production savings to be realized.

The utilities of New York State and the Nation generally are already intensely studying the atomic power problem with plants and programs that are costing over a half billion dollars. New York State utilities are already supplying some 20 percent of the cost of these efforts with the construction of 3 plants, each of different reactor types, which are soon to come into operation: 1 near New York City by the Consolidated Edison Co., 1 in Detroit supported by a group of 17 companies of which Central Hudson, Long Island Lighting, and Rochester Gas & Electric are involved, and a plant near Philadelphia being built by a group of 53 utilities among which are Niagara Mohawk, New York State Electric & Gas, and Rochester Gas & Electric.

Other utility atomic power projects throughout the country will also soon be coming into operation and since each involves various means for attacking this challenging problem, there is much that soon will be learned. Present designs of atomic plants are very expensive and soon tend to become technically obsolete because of the rapid changes in the art. However, since none of these atomic plants now being built, except under very exceptional local conditions, will produce power as cheaply as conventional plants, it is important to take advantage of the experience gained from these efforts if benefits are to result from atomic power that can be passed on to the electric customers of this State.

At the present time New York State will have a surplus of power for the next few years as a result of the recently installed St. Lawrence plant and the Niagara development to come into operation in 1961. Thus the "ample capacity" situation which results will give ESUPRA group time to take advantage of the progress in the art of atomic power and thus avoid the wasting of large sums om money, by the premature choice of a type of reactor less suitable for the needs.

Therefore, when the next major electric generating plant in New York State is needed, its location, type, and design will have been carefully analyzed and prepared. Such a program plan will enable cheaper power to become available to the people of New York State at the earliest possible moment.

FLORIDA POWER CORP.,
St. Petersburg, Fla., March 14, 1960.

HON. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy, Congress of the United States, Washington, D.C.

DEAR SENATOR ANDERSON: My letter of January 29, 1960, indicated that the Florida West Coast Nuclear Group (FWCNG) would file a written statement for the record of the Joint Committee in connection with the section 102 hearings for 1960.

As you will recall, the research and development program for the Florida West Coast Nuclear Group project is being conducted by the East Central Nuclear group (ECNG). A statement as to the status of the research and development program is being provided to you by Mr. Philip Sporn, Chairman, Research and Development Committee, East Central Nuclear Group. The statement by Mr. Sporn is based on a report which Florida West Coast Nuclear Group and East Central Nuclear Group made jointly to the AEC this March.

Florida West Coast Nuclear Group also wishes to report several other developments regarding the Florida project. In September 1959 the selection of a site in Polk County, Fla., was announced. In November 1959 Florida West Coast Nuclear Group was incorporated in the State of Florida. In December 1959

our application for a construction permit and other necessary licenses was filed with the AEC.

The foregoing is a summary of the principal actions undertaken by Florida West Coast Nuclear Group over the past year. If additional or more detailed information on any of these subjects would be of help to you or your committee, we would be pleased to provide it to you or to the staff of the Joint Committee on Atomic Energy.

Sincerely yours,

W. J. CLAPP, *President.*

STATEMENT BY GENERAL PUBLIC UTILITIES CORP.

The purpose of this statement is to supplement information given in a statement dated February 17, 1959, prepared for the 1959 section 202 hearings and to give a progress report on the Saxton hook-on reactor project.

In May 1959 the General Public Utilities Corp. domestic operating subsidiaries formed the Saxton Nuclear Experimental Corp. for the purpose of constructing and operating a 20 thermal megawatt power reactor which will be used in carrying out a 5-year operational type research and development program. This reactor facility will be located at the Saxton steam generating station of the Pennsylvania Electric Co. and will be hooked on to one of the existing 10-megawatt turbine generator units located in this station. The Saxton steam generating station is located about three-fourths of a mile north of the Borough of Saxton, which is situated in central Pennsylvania about 25 miles north of the Pennsylvania Turnpike.

The corporate charter of this new nonprofit corporation provides for participating members in addition to the shareholder members which are the General Public Utilities Corp. domestic subsidiaries. The shareholder members are Pennsylvania Electric Co., Metropolitan Edison Co., Jersey Central Power & Light Co., New Jersey Power & Light Co. The Pennsylvania State University has been accepted as a participating member in this project and it is presently contemplated that one more university from the State of New Jersey may join in the project as a participating member. We believe that participation by universities will be in direct keeping with our objective of advancing the art of generating electric energy by nuclear means. It will also contribute to the universities' own nuclear research and educational programs.

On July 27, 1959, the Westinghouse Electric Corp. and the Saxton Nuclear Experimental Corp. signed a contract under which Westinghouse will: (1) Design, construct, and furnish to Saxton the complete nuclear steam-generating plant, together with certain nuclear and nonnuclear supporting facilities (2) furnish all fuel requirements for the first 5 years of operation after initial criticality; and (3) conduct a substantial preoperational and postconstruction research and development program over a period of approximately 7½ years, including the furnishing of certain equipment and personnel. Saxton will pay Westinghouse the fixed sum of $6,250,000 as the full contract price for the reactor, plant equipment, fuel fabrication costs, materials, and services to be supplied by Westinghouse pursuant to this contract. Westinghouse has also agreed to assume financial responsibility for all special nuclear material needed for the 5-year period of operation as required by AEC regulations, and to pay directly to AEC all AEC charges in connection with such materials. In addition to the payment to Westinghouse of $6,250,000, Saxton will bear the cost of certain modifications and additions to existing conventional facilities at the Saxton steam generating station and will furnish certain other items and services during the design and construction phases of the project. Saxton will also bear the cost of operating the plant, except fuel costs which are to be borne by Westinghouse, during the 5-year operating period. The total financial requirements of Saxton Nuclear Experimental Corp. for the project including provision for contingencies and working capital through the period of design, construction and 5 years of operation are estimated at $8,520,000.

The general purpose of the project as set forth in the agreement between Westinghouse Electric Corp. and Saxton Nuclear Experimental Corp. is to conduct a research and development program over approximately a 7½-year period, including 5 years of operation, which will involve operating a small developmental nuclear reactor under utility company operating conditions with primary emphasis on achieving lower nuclear power costs through exploring the possibilities of increasing nuclear fuel use efficiencies and economies and lowering future nu-

clear powerplant capital costs. It is not anticipated that the reactor plant will be an economic producer of steam for the generation of electric power, and the reactor plant is conceived of, and will be utilized, as an expendable component of this research and development program.

As pointed out in the prepared statement by the General Public Utilities Corp. for the 1959 section 202 hearings, the hookon concept has the immediate advantage of reducing total investment by eliminating the need of purchasing new electrical generating equipment. Also by limiting the size and scale of the investment, it will not be necessary to place emphasis on continuity of operation such as would be necessary for a large-scale commercial plant and the reactor can be considered as an experimental and expendable plant devoted to the development of the art.

The application to the AEC for construction permit was submitted on July 24, 1959. The preliminary hazards summary report, which was submitted as part of this application, was reviewed by the AEC Advisory Committee on Reactor Safeguards on September 10, 1959, and was given a favorable report on September 14, 1959. The formal public hearing to review this application was held on December 15, 1959, and the hearing examiner's intermediate decision directing the issuance of a construction permit was made on January 21, 1960.

The financial commitments of the four GPU operating subsidiaries are contingent upon their obtaining requisite approvals of the Securities and Exchange Commission and the State utility commissions. Applications by the two Pennsylvania subsidiaries. Pennsylvania Electric Co. and Metropolitan Edison Co. to the Pennsylvania Public Utility Commission were made on October 2, 1959, and approval orders were received from this commission on November 30, 1959. A joint application by the two New Jersey subsidiaries, New Jersey Power & Light Co. and Jersey Central Power & Light Co., was made to the Board of Public Utility Commissioners of New Jersey on October 31, 1959, and public hearings to review this application were held on December 4, 1959, and December 14, 1959; the approval order was received from the commissioners on January 8, 1960.

An application-declaration was filed with the Securities and Exchange Commission under the Public Utility Holding Company Act of 1935. It is the general practice of that Commission to defer action on matters which also require State commission action until after the State commissions have acted. The Securities and Exchange Commission has been furnished with copies of the New Jersey and Pennsylvania commissions' orders and we anticipate action by the Securities and Exchange Commission at an early date.

Westinghouse Electric Corp. has employed the engineering firm of Gilbert Associates, Inc., of Reading, Pa., to do the architect-engineering work and to supervise construction. Since the signing of the agreement in July, the plant design has been developed to the point that orders have been placed for some of the long leadtime components such as the reactor vessel, steam generator, and vapor container. Excavation for the vapor container is scheduled to start early in February. The estimated construction time from the date of signing of the contract is 30 months and the earliest estimated date for criticality is December 1, 1961.

We believe that this project which is a cooperative effort involving the General Public Utilities Corp. domestic subsidiaries, Westinghouse Electric Corp., and Gilbert Associates, Inc., will make a valuable contribution toward improving the economics of nuclear energy for commercial power generation.

FORD INSTRUMENT CO.,
DIVISION OF SPERRY RAND CORP.,
Long Island City, N.Y., April 13, 1960.

Mr. GEORGE F. MURPHY, Jr.,
Congress of the United States,
Joint Committee on Atomic Energy,
Washington, D.C.

DEAR MR. MURPHY: I regret exceedingly the delay in forwarding our written statement to you. I sincerely hope it has not inconvenienced you in any way.

The enclosed statements represent the joint position of Isbrandtsen Co., Inc., Maryland Shipbuilding & Drydock Co., and Ford Instrument Co., for the 202 hearings.

If there is any further information I can supply, please do not hesitate to get in touch with us.

Yours very truly,

THEODORE JARVIS,
Manager, Nuclear Development Division.

TESTIMONY BEFORE JOINT CONGRESSIONAL ATOMIC ENERGY COMMITTEE, 1960

I. HISTORY OF PROJECT

Isbrandtsen Co., Inc., Maryland Shipbuilding & Drydock Co., and Ford Instrument Co. joined in the summer of 1958 to study the application of nuclear power to merchant ships. After extensive study, the group decided that an extremely promising course of action would be to install a gas-steam reactor in a vessel such as the S.S. *Hans Isbrandtsen*, a modern tanker, for the production of superheated steam for the vessel's existing steam turbines. A novel concept for the installation of the reactor was worked out. This concept involves building the reactor and a steam generator into a special section of the ship's hull, performing complete tests in a remote location, and then installing the tested reactor in its hull section in the S.S. *Hans Isbrandtsen*, while keeping the remainder of the power machinery intact. This concept and some of its characteristics were presented at the testimony given by Mr. Charles S. Rockwell of the Ford Instrument Co. before the Joint Committee on February 19, 1959.

II. RESULTS ACHIEVED SINCE LAST TESTIMONY

Much work has been accomplished on the design of nuclearized S.S. *Hans Isbrandtsen* since we spoke last at the Joint Committee 202 hearings. This progress has been in the area firstly of the determination of the technical feasibility of construction and testing of a gas-steam reactor in a hull section of a ship. This work has been carried on with both company and Maritime Administration support. The results achieved have been quite encouraging—they indicate that the reactor in its hull section becomes a readily movable vehicle which can be transported to its isolated test site without undue problems and that a relatively simple and inexpensive test site will be adequate for carrying out all significant nuclear and power plant tests ranging from initial critical testing through full power operation. This becomes an extremely economical technique for test and operation of new types of nuclear powerplants in merchant ships.

A study also has been made of the economics of the operation of a converted S.S. *Hans Isbrandtsen*. This work indicates that the *Isbrandtsen* after conversion will have greater cargo oil capacity than she did before conversion. This increase in capacity occurs despite the retention of the present boilers and sufficient fuel oil to achieve take-home power under any possible emergency resulting at sea. Because this same ship has accumulated a substantial amount of operating experience with its present oil-fired boilers, we have a unique opportunity for the direct comparison of the economics of nuclear power operation with conventional operation.

The first core loading of the S.S. *Hans Isbrandtsen* will not be competitive with oil power in view of the necessary development costs and higher initial fabrication costs. But we can expect the fuel costs to go down as subsequent cores are installed. The operating *Hans Isbrandtsen* should be competitive with oil fuel by its second core if credit is taken for the additional cargo oil which can be carried. Based upon an equivalence in operating costs, that is, in mills-per-shaft-horsepower-hour, nuclear fuel will be competitive by the third or fourth core.

III. ROLE OF THE GAS-STEAM REACTOR IN THE U.S. MERCHANT MARINE

Another important achievement in the period since our testimony last year has been the proper assessment of the gas-steam reactor concept in the overall context of the development of a nuclear merchant marine. Our conclusions are two: firstly, that the gas-steam reactor concept occupies a middle role in development time—somewhere between the shorter development period required for aqueous systems (boiling water and pressurized water reactor powerplants)

and longer lead systems, such as the MGCR reactor program with its high-temperature reactor and closed-cycle gas turbine. Secondly, we have concluded that the gas-steam reactor concept has an important future course of development in the merchant marine with long-range objectives independent of other marine reactor systems.

The gas-steam reactor concept offers certain important technical and economic advantages. These are as follows:

(1) Low fuel and capital equipment cost;

(2) High thermal efficiency;

(3) Simple reactor primary loop with a minimum of complex machinery;

(4) Conservative technology used throughout nuclear reactor and primary loop equipment (all other equipment is standard shipboard gear);

(5) No radioactive waste under normal operating conditions;

(6) Good reactor transient performance under conditions of startup, maneuvering, and shutdown; and

(7) Low stored energy in the reactor coolant with consequent reduction of reactor containment problem.

The reactor itself can be considered as the most conservative of all of the advanced gas-cooled reactor systems produced to date. We have taken advantage of the fact that steam pressures and temperatures used in modern land-based power-generating plants are higher than those currently employed in the modern merchant ships. Thus, the helium-gas temperature needed to produce superheated steam for a modern marine propulsion plant is substantially lower (100°–300° F. less) than the reactor coolant gas temperature required for stationary powerplants currently under development, for example, in the advanced gas-cooled reactor project, in the high temperature gas-cooled reactor project by the United Kingdom, and the United States in the Oak Ridge, Philadelphia Electric, and Carolinas-Virginia power reactor developments.

In the future, lighter and more efficient powerplants can be developed than the one we propose for the conversion of the *Hans Isbrandtsen*. When the marine industry uses powerplants capable of higher pressures and temperatures and more efficient operation, the nuclear reactor will keep pace. The use of ceramic fuel elements can be expected to increase operating temperatures while at the same time reduce fuel enrichment, as well as fuel fabrication and burnup costs.

IV. NEED FOR LEGISLATION

As the foregoing indicates, we have made considerable progress toward our objective of converting the SS *Hans Isbrandtsen* to nuclear power. However, as we stated last year, no company or group of companies can afford to carry out the entire cost in the research and development, construction and operation in projects such as this one.

During the recent session of the Congress two bills were introduced which had the objective of supporting cooperative industry-Government nuclear-powered merchant ships. Senator Butler introduced a bill, S. 2336, and a corresponding bill was introduced by Congressman Garmatz, H.R. 8425. These two bills provide for the amendment of the Merchant Marine Act of 1936 by inserting a new title to authorize Government aid in nuclear marine projects. While we feel these bills represent a considerable step toward national objectives, the Isbrandtsen-Maryland-Ford group has no opinions as to whether nuclear marine support legislation should be within the jurisdiction of the Joint Congressional Atomic Energy Committee or the House Merchant Marine and Fisheries Committee or the Senate Interstate and Foreign Commerce Committee.

We respectfully suggest that if it is the intent of Congress that the American merchant marine be converted in some part to useful nuclear propulsion, appropriate hearings on legislation of the sort introduced by Senator Butler and Congressman Garmatz are essential. The use of nuclear power appears to us to offer a possible means for the American merchant marine to regain some measure of the prestige and importance it once had in ocean shipping, and at the same time offers a possibility, through more economical operation, for the eventual lessening of the enormous subsidy burden which it now imposes on the American taxpayer.

THE H. K. FERGUSON CO.,
Cleveland, Ohio, April 19, 1960.

CONGRESS OF THE UNITED STATES,
Joint Committee on Atomic Energy, U.S. Capitol, Washington, D.C.
(Attention: Mr. George F. Murphy, Jr.).

DEAR MR. MURPHY: In response to the Honorable Clinton P. Anderson's letter of January 20 regarding the 202 hearings, we appreciate the opportunity to make the following comments on the civilian power reactor program and the military reactor programs.

CIVILIAN POWER REACTOR PROGRAM

We are in agreement with the objectives of the AEC's 10-year civilian power reactor program. We believe that these objectives can be realized within the scope of the comprehensive development program which the AEC has advanced.

The first objective, "to reduce the cost of nuclear power to levels competitive with power from fossil fuels in high energy cost areas of this country within 10 years," in our opinion, can be accomplished earlier than predicted by the AEC. At the present time there is a substantial design and experience background in the proven reactor concepts. As a result the manufacturers of nuclear components have a better understanding of the requirements, problems, and capabilities of such plants and are more confident of their ability to predict and guarantee performance. This permits plants to be designed closer to actual ratings at lower costs without sacrificing reliability or safety.

It is recommended that more emphasis be placed on nuclear process steamplants in both the low temperature, low pressure, and the high pressure ranges. Such plants could contribute significantly to the nuclear technology and to operating experience. The present program is geared to saline water conversion which is also an experimental program. Results from this program will not aid the nuclear industry for several years.

One of the major factors that may slow down the adoption of nuclear power even after its economy has been proven is the public fear of any and all nuclear installations. It is recommended that a program be initiated to inform the public of the inherent safety of nuclear powerplants and of the many safeguards that are required before such a plant can be erected or operated. It is further suggested that a 10–20 electrical megawatt nuclear powerplant of the sea transportable type be used for demonstration purposes in those areas accessible to navigable waters, to graphically show the simplicity and safety of nuclear plants in general. Such a plant could be used to make the public more familiar with and more ready to accept nuclear powerplants when such plants are proposed for their immediate area.

MILITARY REACTOR PROGRAMS

The military reactor programs should be accelerated and greater industry participation should be encouraged. At the present time there is only a limited knowledge in industry of the objectives and needs of the military reactor programs. We recommend that the military reactor program be broken up into several categories and pursued as follows:

1. Propulsion systems

The propulsion systems program is now well defined and should continue.

2. Reactors for major military bases

The major military bases not accessible to utility grids require large reliable power supplies. Nuclear powerplants of proven design capable of providing the minimum baseload requirements should be provided for these bases to free them from dependence on fuel supplies in case of national or other emergencies.

3. Reactors for remote sites

Reactors should be provided for these sites. In addition to supplying a reliable source of power independent of weather conditions such plants would release supply personnel and equipment for more vital duties elsewhere.

4. Reactors for combat areas

Reactor powerplants should be developed for use in combat areas. These plants should be small and highly mobile, preferably single-package units. Such plants would supply the basic power requirements for modern combat equipment and would relieve the problem of fuel supply to conventional power generating unit.

Very truly yours,

THE H. K. FERGUSON CO.,
C. M. CANTRELL,
Director, Nuclear Division.

U.S. DEPARTMENT OF THE INTERIOR,
BONNEVILLE POWER ADMINISTRATION,
Portland, Oreg., January 27, 1960.

Hon. CLINTON P. ANDERSON,
U.S. Senate, Washington, D.C.

DEAR SENATOR ANDERSON: I appreciate your letter of January 20 inviting me to testify orally or to submit a written statement to be included in the record of the hearings you are preparing to hold on the development, growth, and state of the atomic energy industry.

As a member of the ad hoc advisory committee on reactor policies and programs appointed by the Atomic Energy Commission on October 14, 1959, I participated in a detailed review of the report on th civilian power program by the Division of Reactor Development, U.S. Atomic Energy Commission, and in the preparation of our recommendations to the Commission on this report and on the AEC's 10-year civilian power program. Since I am in substantial agreement with the observations and recommendations contained in this report, which was submitted in the form of a letter to Mr. McCone dated December 14, 1959, it would be repetitious for me to discuss my independent views. I feel that the report presents an ambitious and quite adequate program for both the near-term and the long-range development of economical nuclear power in the United States and in friendly foreign countries.

Sincerely yours,

E. C. STARR, *Chief Engineer.*

KAISER ENGINEERS,
DIVISION OF HENRY J. KAISER CO.,
Oakland, Calif., February 19, 1960.

Hon. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR SENATOR ANDERSON: In response to your letter of January 20, we are pleased to submit our comments for the record on the development, growth, and state of the atomic energy industry.

A. THE AEC'S 10-YEAR CIVILIAN POWER PROGRAM

In last year's "202" hearings we expressed the view that the Atomic Energy Commission's program should include reactor experiments and prototype plants to develop and improve promising nuclear power reactor types and components in lieu of full-scale plants, where the prototypes are large enough to demonstrate adequately the operating characteristics of a full-scale operation. We continue to hold that belief.

We further believe that the AEC should continue to support the investigations of all practicable reactor types, regardless of the fact that commercial incentive may be lacking for some. This support should include, where appropriate, assistance in financing facilities required in these investigations.

We believe that the AEC should continue and increase its use of nuclear, powerplant design studies as a means of selecting appropriate programs to support. Such studies should be based not only on established technology, but also on projected improvements, to determine the economic incentive of striving for such improvements. Such studies may scream out certain concepts which are inherently uncompetitive with other reactor types or conventional power, even with all possible improvements. This screening may obviate research and development, which is much more costly in terms of manpower, time, and funds than are engineering design and cost studies.

We have reviewed the copy of part 4 of the Atomic Energy Commission's "Civilian Power Reactor Program Study" which was recently forwarded to us by Mr. Ramey, and we are essentially in agreement with the objectives presented. We believe the AEC has allowed sufficient flexibility in their program to permit expansion of their planning to allow for additional reactor concepts that may be proposed as promising as time progresses. However, we strongly recommend that their new concepts program be limited to the development of reactor types on which design studies have indicated distinct economic advantages over the more proven reactor types.

B. MILITARY REACTOR PROGRAMS

Under contract with the AEC we have recently made certain design and cost studies on the application of nuclear power at certain remote defense sites. As a result of this work we are convinced that, for certain of these remote military sites, nuclear powerplants would be more economical to operate than fossil fuel plants. We believe the Government should take advantage of these particular situations and should build such nuclear power stations where the operating cost is competitive.

We believe that the erection and operation of any nuclear power facility will provide additional industrial know-how, and will lower the cost of nuclear power components. Therefore, the construction of these military powerplants, if justified in their own right, will contribute to the development of the nuclear industry.

We have no comments with respect to the maritime reactor program as it affects industry, AEC contract policies as they affect industry, or the industrial development and uses of radioisotopes.

We appreciate this opportunity of expressing our views to your committee.

Very truly yours,

KAISER ENGINEERS,
DAVID F. SHAW, *Vice President.*

MANUFACTURING CHEMISTS' ASSOCIATION, INC.,
Washington, D.C., February 25, 1960.

Hon. CLINTON P. ANDERSON,
Chairman, Joint Congressional Committee on Atomic Energy, Senate Office Building, Washington, D.C.

DEAR MR. CHAIRMAN: In response to the invitation contained in your letter of January 20, 1960, the Manufacturing Chemists' Association, Inc., wishes to submit the enclosed commentary for inclusion in the record of your committee's hearings on the current state of atomic energy development in the Nation.

The association's statement deals, in general, with Government competition which affects the development of the atomic energy industry. Industry has facilities and capabilities to supply materials and services for the specific nuclear fuel projects listed in the appendix to the statement. This list was furnished to the Atomic Energy Commission and commented upon in the Commission's letter dated February 10, 1960, addressed to the National Association of Manufacturers and the Chamber of Commerce of the United States, in addition to this association. It is understood that the Commission's letter has been made a part of the record of your current hearings.

In this letter, the Commission has pointed out very clearly the difficulties involved in turning over to private industry projects in the atomic energy field in which national defense is of paramount importance. It should be understood, therefore, that this communication is not intended as a criticism of the Atomic Energy Commission which is cooperating with private industry in a commendable manner.

We respectfully request that you and your fellow Joint Committee members give this letter and the enclosed statement consideration as you engage in your annual review of atomic energy progress.

Sincerely,

J. E. HULL.

STATEMENT FOR INCLUSION IN THE RECORD OF SECTION 202 HEARINGS HELD BY THE JOINT CONGRESSIONAL COMMITTEE ON ATOMIC ENERGY, SUBMITTED BY THE MANUFACTURING CHEMISTS' ASSOCIATION, INC., FEBRUARY 25, 1960

INTRODUCTION

The Atomic Energy Act passed by the Congress in 1954 states that the national effort to develop the application of atomic energy shall be based on strengthening free competition in private enterprise.

Private industry, relying on that policy, has over the past 6 years expended many millions of dollars in the conduct of self-sponsored research and development, in the construction of laboratory and production facilities, and in the assembly and training of technical and engineering staffs. In the chemical field, as in many other areas of atomic energy progress, private industry has made substantial contributions during this period.

Now, private industry possesses the technical competence, the diversified experience, and the necessary facilities to provide, on a competitive basis, nearly all types of products, materials, and services necessary to continued development of applications of nuclear energy.

THE PROBLEM

As industry's capabilities have expanded, the problem of competition from the Atomic Energy Commission, its national laboratories, and its operating contractors has become one of increasing concern.

In recent years, the Atomic Energy Commission has given increasing consideration to the role that private industry should and must play if the atomic industry is to become a healthy, self-supporting business. Some examples of this are:

1. In the building and operation of Government-sponsored power reactors, industry has supplied much, if not most, of the equipment and materials, including nuclear fuel processing on a competitive bid basis.

2. Offered for competitive bid a contract to supply 5,000 tons per year of purified uranium which resulted in the building of a new feed materials plant by private industry to make UF^6 from ore concentrate.

3. Opened up the submarine program to private industry, thus introducing competitive aspects. This, however, was on fuel elements only and to date has not included supply of uranium metal which is currently provided by the Government.

4. Set up the fuel cycle development program to bring competition into the R. & D. field of the nuclear industry. This is excellent, because the policy of bringing private industry into nuclear work during the early phases of a program puts the technology into the hands of private industry where it then becomes the basis of a healthy profitable industry. This policy should be vigorously pursued.

5. Current practice of giving out more of the fuel business on such reactors as BORAX[5] and EBR[1] is commendable, and should not only be continued but expanded.

However, despite the increasing amount of work made available to industry by the AEC since 1954, the efforts of private industry to participate have not been notably successful, particularly in the reactor field. Consequently, industry's role is but a minor part of the total effort toward the national atomic energy development program.

Even in the areas where private industry is presently participating much of it is on a cost-plus-fixed-fee basis. This type of contract serves a definite purpose where initial development costs are high, parameters are not clearly defined, and where necessary facilities do not already exist. However, as soon as possible, a transition to competitive bid contracts is urged, where price and performance are essential if a company is to continue in business.

It is no secret that the immediate prospects for an increase in commercial power reactor business are poor, with potential buyers maintaining a wait-and-see attitude. At least during this period, it is the expressed desire and hope of the Manufacturing Chemists' Association that there will be an ever-increasing amount of nonweapons work made available to the private nuclear industry on a competitive bid basis.

There exist at the present time many specific examples of projects wherein private industry could participate to a greater degree. In the reactor fuel

field alone, a recent survey showed 17 separate fuel projects (see appendix A) now underway in Government facilities, all of which industry is fully equipped and qualified to perform. An outstanding example of a case in which private industry could more fully participate is the processing, fabrication, and testing that the Government will require in connection with the production of fuel elements for the large new production reactor to be built at Hanford, Wash.

The reprocessing of reactor fuel elements is still carried out exclusively by the Atomic Energy Commission. Progress toward industrial participation is indicated by the current IRG studies.

It appears that one of many other areas where the AEC could promulgate this greater participation is in the supply of uranium metal for the submarine program. The letting of contracts in this area to competitive commercial fuel processors would certainly be a giant and positive step in the right direction.

In the early days of the atomic energy program, cost-plus-fixed-fee contracts worked well. From this there evolved some contracts arrived at on a competitive bid basis, which in the case of fuel materials had the extremely beneficial effects of increasing process technology and reducing prices by as much as 50 percent since 1956. We cannot become overly enthusiastic at this, however, because the years immediately ahead, when commercial power reactor business will be at a low ebb, will be difficult ones. In view of this, there must be a vigorous Government policy of increased participation in nuclear business by private competitive industry. Recent promulgation by the Bureau of the Budget of its Bulletin No. 60–2 will, in its application to the AEC, be helpful if the policies contained therein are aggressively pursued.

In summary, commercial fuel processors and fabricators are ready, willing, and able to fully participate in nuclear business on a competitive bid basis.

RECOMMENDATIONS

The Manufacturing Chemists' Association strongly recommends that the Joint Congressional Committee on Atomic Energy reaffirm the national policy, as stated by the Congress in the Atomic Energy Act of 1954, that the national nuclear development effort shall be conducted so as to strengthen free competition in private enterprise.

Further, the association recommends that, in accordance with that policy, the Joint Committee give full support to the principle that Government-owned facilities be used for nonweapon atomic energy research, development, testing, processing, and production only when necessary facilities and capabilities for such work do not exist, or cannot reasonably be provided, in private industry.

There are now and there will continue to be important areas of pioneering research development, and experimentation in which the national laboratories and other AEC facilities should, and probably must, bear primary responsibility. They can best serve the public interest by invading these frontiers of nuclear science rather than trying to duplicate industry's productive capabilities.

APPENDIX A

NUCLEAR FUEL PROJECTS

Following is a list compiled by the nuclear committee of the Manufacturing Chemists' Association, Inc., of specific reactor fuel projects involving chemical technology currently sponsored by the Atomic Energy Commission, for which private industrial concerns possess both technical capabilities and productive capacity:

1. Conversion of all enriched and depleted uranium from UF_6 as required in the nuclear Navy for metals, alloys, or uranium compounds.
2. Provision of depleted uranium for all activities at the national laboratories.
3. Conversion from UF_6 of depleted uranium required for shielding cask at Bettis Field representing approximately 40 tons of cylindrical casting.
4. Conversion and fabrication of fuel elements for the process heat reactor project tentatively scheduled to be built at Point Lomas, San Diego, Calif.
5. Enriched uranium oxide and/or pellets for the gas-cooled reactor project at O.R.N.L.
6. Conversion and fabrication of fuel elements for the AEC's nuclear rocket program at Livermore.
7. Supply of enriched uranium metal for ETR and MTR fuel elements.
8. Enriched uranium metal and fabrication of fuel for the NPR at Hanford.

9. Depleted uranium metal for AEC shielding cask at General Electric, Schenectady.
10. Supply and/or fabrication of high purity cobalt for the High Intensity Radiation Development Laboratory at the Brookhaven National Laboratory.
11. Production of uranium for heavy water components test reactor being built at Savannah River.
12. Conversion and fabrication of uranium elements required for subcritical training reactors for educational institutions.
13. Production of enriched uranium metal for the Piqua reactor.
14. Supply of thorium oxide for the homogeneous development program at O.R.N.L.
15. Supply of thorium metal for special projects at Los Alamos, Sandia, and Lawrence Radiation Laboratory at Livermore.
16. Recovery of cold fabrication scrap, both high and low enriched, from all of the above projects.
17. Supply of uranium oxide and fabrication of subsequent fuel elements for Shippingport reactor.

NATIONAL ASSOCIATION OF MANUFACTURERS,
New York, N.Y., March 1, 1960.

The Honorable CLINTON P. ANDERSON,
The United States Senate,
Washington, D.C.

DEAR SENATOR ANDERSON: Because of our vital concern with the patent provisions of the Atomic Energy Act, the NAM patents committee has prepared the enclosed statement for submittal to your committee in connection with the section 202 hearing.

It would be sincerely appreciated if this were entered into the current record made before the Joint Committee on Atomic Energy.

Very truly yours,

THOMAS M. FERRILL, Jr.,
Chairman, Government Interests Subcommittee of the Patents Committee.

NATIONAL ASSOCIATION OF MANUFACTURERS
OF THE UNITED STATES OF AMERICA,
New York, N.Y., March 1, 1960.

Senator CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Congress of the United States,
Washington, D.C.

DEAR SENATOR ANDERSON: The nuclear energy committee of the National Association of Manufacturers is pleased to submit this statement in connection with the hearings on the development, growth, and state of the atomic energy industry. We should like to comment on competition between the Government and private industry as defined in the Bureau of the Budget Bulletin 60–2.

As I am sure you know, a special task force of our nuclear energy committee reviewed activities in the nuclear energy field as they might come within the scope of this Bulletin 60–2. The results of this review were furnished to the AEC in a letter dated December 4, 1959, from the then chairman of the NAM committee, Mr. J. F. Fairman.

Without attempting to discuss in detail the areas covered in that letter, they generally fell into the category of the fuel cycle (with the excepion of the U^{235} enrichment process), irradiation services, supply of special materials and services. Our task force had determined that an industrial capability exists in all of these areas and should, in our opinion, be utilized in preference to Government-owned facilities.

We recognize that this problem of competition is a complicated one, which will not be solved quickly or easily. It obviously was necessary to operate the Government-owned laboratories during the war for the military program. Further, we certainly agree that the so-called multi-program laboratories of the Commission are still absolutely necessary today in research and development programs in the nuclear field.

However, in this rapidly changing field, private industrial capacity has grown rapidly in the past 5 years, particularly in the areas mentioned above. At the same time, the Government-owned laboratories have also grown both

in total expenditures, and in the number of employees. As these operations have increased, their scope has been broadened considerably from the original research and development objectives.

It is our fundamental belief that in the area of civilian programs, Government-owned facilities should be used only for research and development activities requiring special facilities which do not exist in industry. Other activities should, insofar as possible, be carried on by privately owned facilities, financed with private funds.

Since the Atomic Energy Act of 1954 specifies that one of the objectives of national policy is "to strengthen free competition in private enterprise," we recommend a clear restatement of this policy, particularly as it pertains to the use of Government-owned facilities.

We would also recommend that a mechanism be established to give a continuing review and discussion between industry and the AEC of current programs which are competitive, as well as future ones which might result in competition. As I have said before, it is our feeling that the programs of Government laboratories should be limited to research and development, and even there such programs should not compete with industry. The integrated activities of these laboratories which involve routine production programs should be curtailed, with the aim of cessation at the earliest practicable date.

Programs which have been advanced in the National Laboratories to full-scale development status, and are nearing manufacturing stages, should then be considered for production by private industrial facilities, even though these procedures may result in a temporary increase in time schedules or cost of initial production. Changeovers are simpler at this point and will be cheaper in the long run.

It is our feeling that worthwhile results have been brought about by issuance and consideration of the Bureau of the Budget Bulletin 60–2 and we look forward to future discussions with the AEC in this area. We hope that the joint committee will actively encourage this spirit of cooperation which will lead to maximum contribution to the peaceful development of atomic energy.

Sincerely yours,

LAUCHLIN M. CURRIE,
Chairman, Nuclear Energy Committee.

STATEMENT OF NATIONAL ASSOCIATION OF MANUFACTURERS IN CONNECTION WITH SECTION 202 HEARINGS, 1960

This statement is submitted on behalf of the National Association of Manufacturers with the request that it be entered in the record of the hearings recently held pursuant to section 202 of the Atomic Energy Act. It should be noted that the NAM consists of some 20,000 members of which 83 percent have fewer than 500 employees, and 28 percent have fewer than 50 employees. Therefore, we speak for small, medium, and larger producers as well as a cross section of all types of business enterprises.

Since the enactment into law of the Atomic Energy Act of 1954 there have been many expressions of concern about the patent provisions of this act. The prevailing view of industry is that while the special patent provisions of the Atomic Energy Act were intended to serve the best interests of the Government, the people of the United States and American industry, and to encourage invention and development in the atomic energy field, they actually produce an overall effect which is opposed to these worthwhile objectives. Accordingly, we urge the enactment of such legislation as would place inventions in the field of atomic energy on the same footing as inventions in general fields of endeavor. This can readily be done by the repeal of sections 2181, 2182, 2183, 2184, 2185, and 2189 of United States Code, title 42, and the amendment of sections 2186, 2187, and 2190 to delete references thereto.

With respect to inventions in the atomic energy field, just as with regard to those in other fields, the inventor should have the ordinary opportunity afforded under the Constitution and the patent laws for obtaining U.S. patents and for the full exercise of the property rights, with the choice of exclusive use for a limited time or the sale or licensing of the patented inventions. More-

over, American inventors should have the same opportunity to patent their atomic energy inventions abroad, for their own benefit, as is afforded with respect to inventions in other fields.

It is submitted that the best interests of the Government, the people of the United States, and large and small industries are best served by following the Government contracting procedures in the field of atomic energy which have proved workable and effective for decades for the armed services. By such procedures the Government gets what it needs in the shortest time and at the least cost. At the same time, the country is strengthened by aiding the buildup of healthy industrial companies of all sizes.

The material which follows relates to (1) the need for amending legislation to make U.S. and foreign patent protection and enforcement rights available for inventions in the atomic-energy field in the same manner as in other fields generally, and (2) the importance of retention of commercial rights by the contractors in inventions made during the performance of contracts in the field of atomic energy.

I. The need for amended legislation to make U.S. and foreign patent protection and U.S. patent enforcement rights available for inventions in the atomic energy field in the same manner as with respect to inventions in other fields

There are many indications that, so far as American industry is concerned, the atomic-energy program needs stimulation. Your committee, we are sure, is interested in encouraging the investment of risk capital in research and engineering efforts in this field. However, industry has found that work in this field requires a major investment in research and engineering effort—an investment which companies can afford to make only if patent protection can be obtained. If a company invests in the atomic field and seeks to obtain patents protecting its developments, it has no assurance that it can obtain such patents in its own name and use them in the ways provided for under title 35 of the U.S. Code. Even if it succeeds in obtaining the patents and is not compelled to license them under Commission-imposed terms, it has no way of knowing whether such patents are valid. 42 U.S. Code, section 2185—Prior Art—is a radical departure from our established patent system and creates a hopeless condition as to the evaluation of any patent issued in this art. The threat of compulsory licensing under 42 U.S. Code, sections 2181 and 2183, hangs over any patent in the atomic energy field as a potential devaluating factor. Therefore, while the Atomic Energy Act of 1954 was passed with the expectation that it would stimulate investment of risk capital, these and other patent provisions of that act are inconsistent with those worthy objectives. As a consequence, most research and development being presently carried on in this field is supported partly or entirely with Government funds, and even on this basis is of limited attractiveness, especially to medium and small businesses.

Under U.S. Code, section 2182, all inventions made or conceived under any contract, subcontract arrangement, or other relationship with the Commission shall be deemed to have been made by the Commission. The Commission is in no position to apply for patents or develop these ideas, except in a few cases, so many of them go "down the drain." Indeed, who knows better what is the value of an invention and who is more willing to back it with his time and money than the inventor and his employer. In those few cases where the Government obtains U.S. patents, such patents really serve only as publications, being neither useful in their intended way to protect investment in research and development nor useful to protect the investment of public funds in this type of work.

In view of the foregoing, disproportionate strength in U.S. patents in atomic energy will reside primarily with foreign nationals who secure enforceable patent protection in this country with relative ease while inventors here are largely obliged to forego the patent reward. While this country has been the world leader in research, development, and money invested, it has, sad to relate, a poor patent position in the atomic-energy field.

An issued patent establishes, for all the world to see, the name or names of the individuals making that particular contribution. In the years to come, the history of the development of atomic energy for peaceful purposes will be predicated on the recorded patent history to a large extent.

For the reasons set forth above, we feel that two remedial measures are needed, namely, (1) the removal of the limitations on the patenting of inven-

tions in this field, and (2) a change of the present Commission patent policies with respect to Government-supported contracts.[1]

U.S. inventors lose foreign rights too.—Under 42 U.S. Code, section 2181, the Commission has the right to take the Government contractor's foreign patent rights as well as the domestic. Consequently, U.S. manufacturers are unable to develop foreign patent situations of value such as would aid them in selling abroad or which might aid them in offsetting the patent rights of foreign nationals.

While foreign governments and foreign nationals are working diligently to establish strong patent positions, the United States is permitting the foreign patent rights on American inventions in this field to go largely by default. The American manufacturer endeavoring to do business in foreign countries is faced with the overwhelming patents and competition of foreign interests.

The treaties or arrangements which our country has made with foreign governments are of little assistance to the U.S. manufacturer who is endeavoring to do business abroad on a private-enterprise basis. Government contractors should be encouraged to obtain foreign patents at their own expense. Title to such patents should reside in the contractor subject to a free, nonexclusive license to the U.S. Government.

The atomic energy statutes should be so revised and Government contracts should be so written as to encourage contractors to develop patent situations at their own expense in foreign countries. Such a comprehensive foreign patent situation would comprise a most effective means for demonstrating the technical contributions of the United States to the world. Further, it would facilitate sales of apparatus by American manufacturers abroad and the licensing of foreign manufacturers. Also, it would provide incentive for U.S. investments abroad by enabling American companies to set up to manufacture and sell overseas without having their inventions promptly copied.

Compulsory licensing retard development.—When the patent provisions of the 1954 act were drawn, the conditions obtaining were quite different from those of today. At that time, it was feared that a few companies who had been deeply involved in this development might monopolize this business. In the fear that a few of these insiders might obtain a patent situation dominating the entire industry, the compulsory licensing provisions were enacted. Today, there is no real threat of domination of the atomic energy field by one company or a few companies. As the fundamentals of atomic energy are well known, the inventions that are being made are necessarily confined to improvements. When a manufacturer finds a patent of his competitor to stand in his way, he is led to do original development work to avoid the patent, often resulting in a still better solution to the problem. This process of designing around the patents of others gives the buyer a choice of a number of different designs and frequently results in many improvements being made over the earlier devices on the market, ultimately making better products and services available at lower cost. The compulsory licensing provisions of the Atomic Energy Act defeat this progress incentive which is generally afforded under our patent laws, and thus are contrary to the sound intent and purposes of the act.

II. The importance of retention of commercial rights by the contractors in inventions made in the course of atomic energy research and development

In the field of atomic energy, as well as in the field of astronautics, there has been a great deal of interest in the factors for and against Government acquisition of title to the patents arising from inventions made by contractors in the course of research and development contracts with the Government. On the question whether the Government's policy should be that of requiring only free license rights, as long practiced in defense development contracts, or should be that of acquiring title to the invention, each of the following aspects must be examined:

1. Incentive to enter into research and development contracts;
2. Financial benefit to the Government;
3. Commercial adaptation of inventions; and
4. Discrimination against small business.

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[1] One policy matter of special, current concern relates to the requirement in certain instances that patent rights to background or basic patents be assigned to the Government as a contract provision. This requirement has been made even for fixed-price production contracts involving no research and development. This is a most serious matter, for inevitably it tends to drive away the best qualified firms from entry into AEC contracts.

1. *Incentive to enter into research and development contracts.*—The acquisition by the Government of title to patents, as provided under 42 United States Code, section 2182, significantly reduces the incentive of both large and small companies to enter into contracts with the Atomic Energy Commission.

Contracts for research and development for a branch of the Department of Defense are, in general, reasonably attractive to small and large companies alike. Well-known disadvantages of such contracts are the limitations on the profit to be directly produced through research and development contracts and the lack of certainty of any substantial production and sales to the Government ensuing therefrom. These disadvantages are offset by the opportunities often afforded to the holders of research and development contracts to adapt inventions made in the course of the contract to fields of possible commercial interest, leading to the development of new or improved commercial products or processes. Such commercial adaptation usually entails investment of considerable time, effort, and expense on the part of the contracting company, an investment which it is willing to risk in the expectation of ultimately bringing forth a profitable product and which it is justified in risking if it has patent protection against immediate competition from the ever-present copyist. This prospect is attractive to companies large and small; it is more often of vital importance to small companies who rely more on innovation and improvement for success than large capital and plant facilities.

In contrast, let us examine now the outlook presented to a company undertaking a research and development project for the Atomic Energy Commission on the basis prescribed by 42 United States Code 2182. Very little, if any, benefit accrues to such a company from the successful performance of an adequately funded AEC contract or subcontract. No ownership of U.S. and foreign patent rights is assured, since title to inventions developed in the course of the contract must be conveyed to the Government.[2] Accordingly, the possibility that an AEC contract will lead to a risk-justifying commercial opportunity is dangerously diminished, and the attractiveness of such contracts to private companies, small as well as large, is seriously lessened.

2. *Financial benefit to the Government.*—The Government is not in a position to function as an effective purchaser and exploiter of commercial rights in patents, since the ownership of a patent by the Government has the substantial effect of laying open to the public the commercial rights therein. Unlike the Government, a private owner of a patent on a commercially significant invention, being able to enforce the patent against infringers who choose to ignore it, is accordingly in a position to establish licenses for reasonable value.

The Government obviously is not in a position to enforce patents which it owns against unlicensed commercial users of the patented inventions. The institution of suits by the Government for the infringement of Government-owned patents is unthinkable, and would be remote from the constitutional purpose for which patents are granted. Unless the Government is to be placed in the unprecedented position of threatening prosecution of commercial infringers and following up unheeded threats with legal attacks, it would not be in a position to persuade commercial users of the patented inventions to accept licenses requiring the payment of royalties to the Government. Accordingly, it is illogical and impractical for the Government to seek to establish itself as an effective owner of patents and dealer in commercial rights thereunder. On the other hand, real financial and other benefits flow to the Government by using the incentive value of the patent system to make it possible to get a better job done at a lower cost by the best-qualified parties.

3. *Commercial adaptation of inventions.*—The adaptation of inventions made in the course of Government contracts to commercial processes and products is retarded, rather than expedited, by Government ownership of the commercial rights thereto. Since industrial companies, in general, endeavor to channel their energy toward development of new products which can be protected by patent coverage, the Government's acquisition of ownership of the inventions

[2] There is a provision in 42 United States Code, sec. 2182, which gives the Commission the right to waive its claims to any invention or discovery made under or in connection with a Government contract. However, as one would expect, this waiver provision has been used very sparingly, since an employee of the Commission would appear to be protected from future criticism only by the exercise of extreme conservatism in acting upon waiver requests.

made in the course of AEC contracts has an effect almost like that of dedication of such inventions to the American public. Hence, when an R. & D. contractor in the atomic field develops a commercial adaptation of a Government-assigned invention and brings it to market, he runs the risk that his costs may not even be recovered before competitors rush in to participate in the business, unfairly capitalizing on the result of the initial developer's labor and risk.

Government ownership of patent title again is seen as a deterrent rather than a stimulus for commercial development of inventions when one considers the contrast between the favorable climate for commercial invention development in the company originating the invention, and the less favorable attitude toward the invention likely to be encountered in other companies which ultimately learn of it. In general, a company in which an invention has evolved through the initial stages of conception and evaluation provides the most favorable environment in which to carry out the adaptation and development of the invention to commercial uses. It has the background and technical know-how without communication problems, and it has the enthusiasm and pride of authorship. The retention of commercial rights enhances the likelihood that the contractor originating the invention will carry it through the necessary steps to make its benefits available commercially. Conversely, under Government ownership of the patent, a risk-justifying commercial opportunity is dangerously diminished, and the attractiveness of such contracts to private companies, and particularly the small companies, is seriously lessened.

4. *Discrimination against small business.*—The retention by the contractor of title and commercial rights in patents resulting from Government R. & D. contracts, with the grant of license rights only to the Government, is desirable and important to all potential contractors, and particularly so to small companies. The larger industrial companies can sometimes afford, even though reluctantly, to enter into a contract with the Government under which they face the prospect of retaining no commercial rights in resulting inventions. In some cases, they may rely upon their own patents in allied fields, and/or their potential as suppliers of stock components and equipment, as the route for realizing substantial benefit from such a contract. Small companies, on the other hand, can ill afford to direct their limited manpower and capital toward R. & D. contracts under which the Government would acquire all patent rights, commercial as well as governmental, and foreign as well as domestic, as called for under 42 United States Code, section 2182. Such companies, endeavoring to grow strong in a technical field, stand in especially great need of acquiring at least the commercial rights in a few patents at an early date, so as to be in a position to demand recognition of such rights from larger established competitors and to bring about some offset against the broader patent holdings of competing firms.

In summary, the Government's acquisition not only of free license rights in inventions produced by contractors, but of the entire rights in the patents thereon, is unproductive of benefit to the Government, because (1) it tends to reduce the incentive for potential contractors to enter into research and development contracts with the Government, (2) it is unproductive of any economic benefit to the Government, (3) it is inimical to the most favorable conditions for development of possible commercial adaptations of the inventions, and (4) it is of greater detriment to small companies than to large companies.

RECOMMENDATION

For the reasons set forth above, it is our recommendation that the Atomic Energy Act of 1954 be so amended as to place inventors and Government contractors in this field in the same position, patentwise, as in any other general field. Only by providing such stimulation will the United States insure its world leadership on an economical basis. To this end, we recommend that:

1. All reference to patents be deleted from the Atomic Energy Act of 1954 with the possible exception of those provisions relating to weapons, secrecy, or compensation so that, in the nonweapon field, there will be a uniform patent law applicable to all inventions; and

2. The contracting proecdure of the Commission be revised to afford the contractor ownership of U.S. and foreign patents covering inventions and discoveries arising out of or resulting from Government contracts, such ownership to be subject to a free, nonexclusive license to the U.S. Government to make or have made for governmental purposes.

STATEMENT OF ANGUS MCDONALD, COORDINATOR OF LEGISLATIVE SERVICES OF THE NATIONAL FARMERS UNION, ON THE DEVELOPMENT, GROWTH, AND STATE OF THE ATOMIC ENERGY INDUSTRY

Mr. Chairman and members of the committee, our impression, after reviewing several documents, including the "Civilian Power Reactor Program, Part 4, Plans for Development," by the U.S. Atomic Energy Commission and several addresses by members of this committee is that atomic energy development in the United States is in a state of confusion and that the Atomic Energy Commission has fallen down on the job in advancing peaceful uses of the atom.

It will be recalled that after the revision of the Atomic Energy Act of 1954, the Commission put together a so-called 5-year program at the insistence of this committee. This program was little more than a recitation of the individual projects which has already been undertaken by the National Laboratories. In actuality, the Atomic Energy Commission has no program and since that time has consistently fall down on the job of spelling out a program and carrying it out. The Atomic Energy Commission seems to suffer from a permanent neurosis caused by its obsession that it would be unwise or perhaps unpatriotic or un-American to carry out a Federal program. It has sat back year after year and waited for private industry to do the job. Private industry on its part by means of full-page newspaper and magazine advertisements has attempted to convince the Congress and the American people that it would rapidly inaugurate and carry out a full-scale nuclear program without any subsidies whatsoever.

For example, in 1956 independent electric light and power companies (which incidentally had had nothing to do with the development of atomic energy) came out with full-page advertisements in all of the metropolitan newspapers. In those ads the power companies boasted that they had a number of large atomic energy plants under construction and many more planned. The program of the power companies has fallen on its face. While several plants are under construction, private power companies, at the present time, are not producing a single kilowatt of nuclear power. Furthermore, they have come back to this committee and the Congress repeatedly and have asked for and received huge subsidies. The Congress has been very generous but even with much assistance little has been accomplished. Although several large plants are under construction there has been delay after delay and huge increases in the first announced cost of the projects. The latest information to reach us is that Detroit-Edison project, masterminded by Walter Cisler, has fallen by the wayside. Something is wrong with the core of the reactor we are told which is like saying that the automobile is OK except the motor is no good.

Despite the fact that the Atomic Energy Commission predicted that we would have about 2 million kilowatts of nuclear electric power by the end of 1960, and 5 million by the end of 1965, there has been only one large-scale reactor built in the United States. It now appears that less than 400,000 kilowatts will be in operation by the end of this year.

Efforts to launch and carry out an atomic energy program abroad have also been unsuccessful. The European Atomic Energy Community, composed of six nations, has also failed to get its announced goals. Former Chairman Strauss announced that 15 million kilowatts of atomic power would be developed by these countries by 1967. Although Congress has authorized assistance and although AEC has seemed anxious to build foreign atomic plants, except for one plant in Italy which was planned before the program was set up, no proposal was submitted.

The prospectus of AEC previously referred to gives little encouragement that any plants will be built in the near future. It is recommended that experimental and research programs go along at a leisurely pace for a few years and then AEC will take a look and see if the building of any nuclear plants seem economically justified. On page 3 of the document, AEC trots out its five objectives again for a civilian power program. The first objective is to reduce cost to a competitive level with conventional plants in high interest cost areas. Then on page 5, the Commission says that light water-cooled reactors in the near future can achieve competitive power in the high fuel cost areas of the United States. This would seem to cancel out the 10-year objective unless it means that 10 years from now is in the near future.

It would appear that our recommendations of previous years in regard to the building of large plants should be repeated at this time. Other countries, including the Soviet Union and Great Britain, have gone ahead and passed us if

the measure is the number of kilowatts produced. The Chairman of the Atomic Energy Commission announced recently that the Russians were neck and neck with us. If he is correct and we believe his statement is a conservative one. the United States should immediately embark on a large-scale atomic energy program in which a number of large-sized and small-sized plants could be built.

It has been suggested that the bookkeepers of the budget-conscious individuals in the administration have prevented the presentation of a realistic electric power atomic energy program. Whether or not this is true, we urge the committee once again to consider the Gore-Holifield type of legislation which authorized a large-scale program.

In the last few days, the head of the Atomic Energy Commission has announced that two west coast utilities are now prepared to build two huge atomic plants having a power output of 6 to 650 million kilowatts. Chairman McCone insists that no Federal money will be needed for these projects, except for research and development assistance. We hope that these plans are made realistically and that the utilities will actually do what they say they will do without Federal assistance.

However, if these two utilities can build two economically feasible plants it would seem that the AEC goal to develop competitive nuclear power in high-cost areas in 10 years has no relation to presentday realities. We are aware that such authorities as Admiral Rickover have said it would be some years before competitive nuclear power could be developed. We have called attention to the fact that public power utilities in the past have been unable to produce competitive power. Therefore, we suggest that any new plans and promises by the utilities be carefully scrutinized by this committee.

NATIONAL RURAL ELECTRIC COOPERATIVE ASSOCIATION,
Washington, D.C., February 17, 1960.

Hon. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy, United States Capitol, Washington, D.C.

DEAR SENATOR ANDERSON: As we informed Mr. George F. Murphy of your staff, it will be impossible for any of the qualified members of our staff to appear formally before your committee to testify on the "development, growth, and state of the atomic energy industry." The time scheduled for your hearings coincides with the National Rural Electric Cooperative Association's annual meeting and consequently, we will have to be out of town.

In view of this, we would like to express our views to you and your committee in this letter and ask that it be made a part of the official record.

BASIC POSITION REMAINS THE SAME

Our basic position remains unchanged. Our association has adopted the following statement of policy: "We * * * firmly believe that abundant electricity at low cost is vital to the well-being of rural America. * * * We support the full development as needed of power resources wherever found, whether in the area of hydro, atomic energy or the fossil fuels. * * * We recognize that the peaceful atom today represents a national resource created solely by the expenditure of billions of tax dollars. The people, and not any private corporation to the exclusion of the people, are entitled to the benefits from the vast source of tremendous power potentially available. We believe the national interest calls for prompt and aggressive Federal development of the peaceful atom as a power source."

We believe that it has been amply demonstrated since passage of the 1954 amendments to the Atomic Energy Act that we cannot rely on any program that places complete or major emphasis on commercial utilities, if we are to achieve competitive nuclear power in any reasonable period of time.

We believe the record of the last several years, with the promises held forth and the failures experienced, provide ample support to the above statement.

As to the specific recommendations and observations, I would state the following:

RURAL ELECTRIC COOPERATIVE'S PARTICIPATION

1. I would like to reemphasize the major reasons why the rural electric cooperatives remain adamant in their stand regarding participation in the atomic energy program. We are convinced that as time goes on, the generation of

electric energy from nuclear facilities will become more and more important. This being the case, if the rural electric cooperatives are to survive as electric utility systems, we must develop personnel technically competent in this highly specialized field of atomic energy. Moreover, we must have development suited to the particular needs of the rural electric cooperative systems. This means, as you realize, emphasis on a specific size that otherwise may not get attention. We are interested in the general range of 5,000 to 50,000 kilowatts.

These two main factors, the matter of developing competent personnel and assuring development of economic nuclear power plants in the small- and medium-size ranges, are necessary to maintain survival of nonprofit electric utilities in this country. They are the compelling reasons why we continue to speak about our program before your committee.

PRESSING NEED FOR COMPETITIVE NUCLEAR POWER

2. We believe the pressing need for immediate development of competitive nuclear power warrants the establishment of early goals for achievement of such competitive power. We believe both domestic—especially in the high-cost fuel areas—and international needs demand more rapid acceleration of our nuclear program in this country. Certainly, it does not seem to us to be a good research technique to establish goals 10 to 15 years off in the future for the conclusion of studies leading to usable economic nuclear-reactor technology. Rather, we believe, that if these goals were established to demand the completion and fruition of competitive nuclear-reactor technology within say, the next 2 to 5 years, the situation created would be such that if the program under these "ground rules" were not frustrated, such goals could be achieved.

ROLE OF NATIONAL LABORATORIES

3. The above point leads us to comment on the suggestions and statements recently made calling for the abolition or severe curtailment of the personnel and functions of our national laboratories. We believe that the public investment in these national laboratories, the excellent "research teams" that have been built up as a result of this public investment, and the public need, not only demand that the national laboratories be continued as integrated entities, but that, indeed, the activities of these national laboratories be increased. The public investment in these facilities and in the personnel who comprise them demand that their activities and functions be used to benefit the entire Nation and not any specific vested-interest group. We feel it would not be in the public interest to curtail these functions and thereby provide the way for private industry to pick up these fine public researchers and place them on private payrolls to make use of the knowledge which has been gained from a substantial public investment.

LIMITATIONS OF RESEARCH

4. We also feel it is not in the best interest of anyone concerned to limit—as we believe the AEC is attempting to do—research and development in the nuclear energy field to only three basic reactor concepts. It should seem apparent—especially at this time, with some 10 years experience behind us—that we do not know enough about the various types of reactor technology and their possibilities. It would, therefore, seem foolhardy to suggest and initiate a program whereby we limit research and development to only three basic reactor types or concepts. All indications point to the need for more study and extensive research on a multitude of reactor types and technology.

Not only should our research concern itself with a broad variety of types but construction of experimental prototype plants should also be undertaken immediately across the whole range of sizes and types.

In this same vein, we believe that the research projects which have been concluded and which point to the immediate need for prototype construction of plants for experimental and practical knowledge should be built immediately. I have in mind, for example, the statement recently made by Frank Pittman of the Atomic Energy Commission in which he pointed out that we are on the threshold in our research and development of a 300,000-kilowatt pressurized water plant which could be built to produce competitive power at least in some areas of the United States. It is our feeling that such research projects which are so close to successful research completion should be pushed most

rapidly through the construction stage so that we can actually test out these concepts.

The Pittman report also concluded that with some further successful research and development it would be possible to construct in the near future large-scale boiling-water and organic plants which would produce competitive power in high-cost fuel areas.

It seems to us that it is a tenet of successful research that prototypes must be built and experimented with if we are going to be able to check in any definitive way on the "drawingboard concepts and conclusions." It seems to us that the actual construction of these prototypes must be undertaken if we are to learn about the areas in which costs can be further reduced because these areas generally will not be observable in the theoretical stages.

CAPITAL SUBSIDIES

In all probability, the issue of capital subsidies, in one form or another, will be before the Joint Committee on Atomic Energy again this year. Our position on this matter was presented in some detail to the committee last year. We remain completely opposed to the granting of capital subsidies to commercial utilities for participation in the atomic energy program.

As you are well aware, the existing private reactor projects are recipients of a multitude of subsidies including such things as the Government's research program as conducted by the national laboratories, the Government's guaranteed price for plutonium, the fuel loan program, the subsidized price of enriched uranium fuel provided by the Government, the Government's fuel reprocessing program, research and development subsidies, and others.

The existing subsidies, in the face of the now obvious exaggerated statements made by the spokesmen for the private utilities in 1954, have certainly proved a failure in the stimulation of development that was projected based in large part on these statements.

As the Chairman of the Atomic Energy Commission has himself pointed out, the establishment of a capital subsidies program would open "Pandora's box." We certainly feel the American people should be protected against this.

For these reasons, plus others as pointed out to the committee last year, we feel there is no justification for the establishment of a capital subsidy program from the commercial electric utilities.

RURAL ELECTRIC COOPERATIVE AND MUNICIPAL PARTICIPATION IN THE ATOMIC ENERGY PROGRAM

As the committee knows, rural electric cooperatives and municipals, after a slow and sporatic start, are now participating in several Government reactor projects. These include the Elk River, Piqua, Consumers Public Power, and the Puerto Rico projects. In addition, under a recent announcement, two more second round type projects will shortly be underway.

We appreciate the continued interest and support of the Joint Committee in assuring our continued participation in the atomic energy program and the more recent interest evidenced by the Atomic Energy Commission in our behalf.

We trust that the momentum of this participation will not slow down, and, indeed, if anything, will be increased.

THE HANFORD REACTOR PROJECT

We believe the Congress should authorize the conversion of the Hanford plutonium production reactor to a dual-purpose plant. As you know, this will provide for the production of 700,000 kilowatts of power. We feel this authorization is most justified since, as the studies have shown, converting Hanford into a dual-purpose reactor will enable the Government to produce plutonium at a substantially reduced cost and, in addition, provide about 350,000 kilowatts for the Northwest.

COMMENTS ON THE ATOMIC ENERGY COMMISSION'S CIVILIAN POWER REACTOR PROGRAM—PART IV PLANS FOR DEVELOPMENT

We have just received AEC's detailed discussion of the civilian power reactor program. We feel called upon to make several comments on this proposed program as submitted to the committee.

We are somewhat shocked and dismayed by the proposal in that we feel the program proposal rather than signifying a great step forward, carries out in effect the policies of the previous Chairman of the Atomic Energy Commission. I believe a detailed analysis of the proposed program will support this statement.

The proposed new starts by the Atomic Energy Commission as detailed in their program report calls for, in effect, no new starts prior to either the early 1960's if promising, or 1963 or 1964. The Atomic Energy Commission's program seems to be somewhat less than progressive in that the general tenor is one of waiting to see what will happen by 1963 or some later date and then determining what new projects if any will be started.

Again we find the Commission setting a target date for so-called competitive nuclear power in high-cost fuel areas by 1968. The Commission seems to be playing both sides of the field in this matter. On the one hand, the Commission states that we will wait till 1963 or 1964 to see what new projects will be undertaken; on the other hand, the Commission states we will strive for competitive power by 1968, and juggled up in the air between both hands, the Commission reports that in several instances a 300 MWe plant of several types can now be constructed to provide competitive power in high-fuel cost areas of the United States.

If this last statement is correct, if competitive nuclear fuel can now be produced in high cost areas, why isn't the Commission recommending the construction of such plants? If these plants can be built and they are competitive, why then call for competitive nuclear power by 1968? And further, if the policy of the Commission is one of waiting until the existing projects under construction are completed and operated for a period of time before determining what new projects will be undertaken, how can the Commission argue that by 1968 we will have competitive nuclear power in any or several areas of the United States?

A reading of the proposed AEC program leads us to the same conclusion we have made many times in the past. And this is the simple fact that without the continued prodding of the Joint Committee on Atomic Energy—without the continued prodding of the Congress—there would today be little or no civilian atomic energy program in the United States. A listing of the existing civilian atomic projects as detailed in the Commission's report and an analysis of this listing as to where action was initiated for the undertaking of such construction would, I believe, firmly support the preceding statement.

This logically leads us again to the same point and position we have taken before this committee several times in the past. That is the simple fact that if the United States is to have a successful civilian atomic power program, if we are to maintain world leadership in this area—criteria set forth by the AEC itself—if we are to have competitive nuclear power in the United States in any quantity within the next several years—if all these standards are to be met, they will not be met unless the Congress develops a strong Federal program for the construction of demonstration, prototype, and commercial-size nuclear power stations. Such a program backed up by a strong national laboratories system must be developed, we believe, if we are to have a program at all in the United States.

From the AEC's civilian power reactor program report, we were dismayed to learn that the role of the rural electric cooperatives and other nonprofit utilities in the United States is to be diminished. Other than for the existing projects underway and the two proposals which the Commission has recently released for nonprofit utility operation participation, there seems to be little or no reference in this recent program proposed by the Commission to continued participation by these nonprofit utilities in the future. The report does make the statement that "this emphasis on large central station powerplants should not be construed as indicating a diminution of Commission interest in, or support of, a small power reactor program directed to achieve economically competitive nuclear power in plant sizes below 50 MWe (electrical megawatts)." The report also makes somewhat nebulous recommendation that sometime in the late sixties there may be another project available for these nonprofit utilities. Except for these two statements, there is nothing to give the rural electric cooperatives and municipalities status or participation in the future programing of the AEC as set forth in their program proposals.

As we pointed out previously, we feel that the rural electric cooperatives and other nonprofit utilities throughout the country must maintain continued interest and participation in this atomic energy program if they are to survive in the

future. We feel, therefore, that any program proposed by the Atomic Energy Commission or the Congress must include an adequate number of projects—such projects being proposed under terms which have meaning; namely, the second-round type ground rules—if these utilities are to survive in the future.

Thank you for this opportunity to submit our comments to the committee on these 202 hearings.

Sincerely yours,

CLYDE T. ELLIS, *General Manager.*

NEW ENGLAND ELECTRIC SYSTEM,
Boston, Mass., February 11, 1960.

Hon. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Washington, D.C.

DEAR SENATOR ANDERSON: I want to thank you for your invitation to submit a statement in connection with the Joint Committee's annual section 202 hearings.

As indicated in my letter of a year ago, New England Electric System plans to build a nuclear powerplant of 200- to 300-megawatt capacity for completion in the mid-1960's. Recent studies of the probable power costs from a plant of this size are encouraging and tend to confirm our earlier opinion that such a plant will compare favorably with conventional generating capacity to be built in the New England area a few years hence.

Our advance planning for additional capacity in the near future leaves us flexibility as to the timing and details of this plant. However, we have made preliminary decisions as to possible sites and will be in a position to go ahead expeditiously when load growth indicates the need for a plant of this size in our system.

I should add that our participation in the yankee atomic project has been an important factor in our decision to move forward with a second-generation nuclear plant, and will provide a useful backlog of experience in carrying out the project.

Yours very truly,

IRWIN L. MOORE.

THE NEW YORK PATENT LAW ASSOCIATION,
New York, N.Y., February 15, 1960.

Re Atomic Energy Act section 202 hearings.

Hon. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy, Senate Office Building,
Washington, D.C.

DEAR SENATOR ANDERSON: On receipt of your letter of January 20, in which you invite the New York Patent Law Association to present oral testimony if we have new or different information or views which we believe should be brought to your attention, I referred the matter to the association's committee on Atomic energy and space and asked for the committee's views.

Except for a stronger than ever sense of urgent need to amend the patent sections to prevent further stifling of inventive contributions from individual or private sources, the committee has no new or different information or views. The committee has studied the statement presented on April 22, 1959, on behalf of its predecessor committee by Mr. William H. Davis, who was then chairman of the predecessor committee (transcript of hearings before the Subcommittee on Legislation of your committee, pp. 115–118[1]) and strongly endorses Mr. Davis' statement. A copy of that statement is enclosed herewith, and the committee has asked me to request that it be placed in the record of the hearings of your full committee.

New information was presented in the related field of patents on space activities, however, in the hearings of November 30 to December 5, 1959, before the Subcommittee on Patents and Scientific Inventions of the House Committee on Science and Astronautics, and our committee believes this information should be of vital interest to you insofar as it bears on Government patent policies generally. Particularly interesting are the discussions in those hearings of in-

[1] "Hearings on Atomic Energy Patents," Apr. 21, 22, and 23, 1959.

dustry's reluctance to take contracts because of the NASA patent provisions. (See transcript of hearings, pp. 384 and 412.)

The committee's views in the space field, as distinguished from new information in that field, are expressed in the statements of Mr. Davis, who appeared at the space hearings on December 4 on behalf of the Patents Committee of the Association of the Bar of the City of New York, and of Mr. Floyd Crews, who appeared on December 5 on behalf of our association. (Transcript of hearings, pp. 468–470 and 539–542.)

Yours sincerely,

J. B. L. ORME, *President.*

NORTHERN STATES POWER CO.,
Minneapolis, Minn., January 29, 1960.

Hon. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy, Congress of the United States, Washington, D.C.

DEAR SENATOR ANDERSON: This is an acknowledgement to your letter of January 20 inviting us to testify before the Joint Committee in connection with the 202 hearings in February 1960. You have indicated that you would like us to testify orally only if there is some new or different information which we would like to bring to the attention of the committee. We believe that we can satisfy the requirements of the situation by the following written statement. We are, nevertheless, willing to have a representative appear at the hearing in the event the situation should change and you were to request such an appearance.

The Northern States Power project, the Pathfinder Atomic Power Plant, is proceeding on schedule. We anticipate receiving our construction permit about March 1, 1960. Preliminary work is being done in the field with the expectation that full-scale construction will begin in the spring of this year. To this time we have found no reason to materially change our estimates of cost. We have had excellent cooperation from the Atomic Energy Commission staff in solving the various problems which have arisen.

It has become increasingly clear to us that solution of the economic problems of atomic power is not easy, in terms of either capital costs or operating costs. Of the latter, fuel costs are a very important component. For this reason Northern States Power Co. has joined with four other reactor operators (or prospective operators) and the Davison Chemical Division of W. R. Grace & Co. to make a thorough study of the economics of a privately owned and operated fuel reprocessing plant designed to meet the particular requirements of the participants in the study. The study is being led by Davison and has the full cooperation of the Atomic Energy Commission. It is contemplated that the participants will construct a reprocessing plant if the study confirms present rather reasonable hopes that such a plant will prove economical.

It appears to us that the Atomic Energy Commission's civilian power program is developing satisfactorily. It is exploring a very broad field and is placing emphasis on promising methods. We are particularly in accord with the emphasis being placed on fuel and fuel-cycle development. We feel that the ultimate solutions to the problem of economic atomic power lie in the fuel cycle. It is our recommendation that maximum effort be exerted in this area.

We appreciate the opportunity to present our views and we stand ready to cooperate in the event you should request any further information or assistance.

Very truly yours,

ALLEN S. KING.

STATEMENT TO JOINT COMMITTEE ON ATOMIC ENERGY, CONGRESS OF THE UNITED STATES, SECTION "202" HEARINGS BY A. A. MICHAUD, VICE PRESIDENT, NUCLEAR CORPORATION OF AMERICA, ISOTOPES SPECIALTIES COMPANY DIVISION

Our company, Isotopes Specialties Co., is a division of Nuclear Corp. of America. For approximately 8 years we have been a commercial supplier of radioisotope-based products to American industry, agriculture, medicine, and education. During this period we have had our ups and downs along with everyone else in the industry. We have been carried along on the vibrant enthusiasm of many speakers in both industry and Government. We have been brought up short and hard against the harsh realities of the industrial picture.

We have found that, in our opinion, the development and growth of the atomic energy industry is beset with many complicated and difficult-to-handle problems. I personally feel that in the optimistic days of atomic energy industry many of these problems were either not clearly seen or were ignored in discussing industrial progress. Consequently, when we now meet these drawbacks they are greatly magnified and appear to present unreasonably large obstacles to our atomic energy industrial progress.

Perhaps one of the clearest examples of this type of interference is that of the low level waste disposal situation. It hardly seems necessary to point out that as radioisotopes are used, radioactive waste byproducts are also produced. It is very difficult to see how, in the early days of optimism, that the complete picture was not seen to include the problems of handling these waste products. Great emphasis was placed on the savings industry would make in using radioisotopes. Considerable energy was spent in developing new industrial utilization of radioisotopes. At the same time, and strictly proportional to the success of radioisotope utilization, radioactive wastes were produced. I refer here to the low-level waste that even includes things like cleaning tissues and cotton swabs used in wiping encapsulated radioactive sources. Common things, such as wiping rags, floor sweepings, pieces of pipe, and even shower water, represent these radioactive waste materials. These very unromantic materials have plugged the normal stream of industrial utilization of radioisotopes. Within the past month we in California have seen a fantastic mess generated over handling radioactive waste. The Long Beach story was complete with roadblocks, claim and counterclaim, flying trips by AEC representatives, and even the last-minute apearance of the Coast Guard commandant in charge of the port. Here was a grimly sad situation in which a multi-million-dollar industrial set of gears was well sanded by a pitiably small amount of real problem and an extremely large amount of confusion.

The effect of this situation has been adverse in the local market. People who were fairly close to isotope utilization are now placing great emphasis on the caution that must accompany such use due to these waste disposal fiascoes. The success of our company (and I am sure all the others in this field) depends on selling radioisotope applications to industry. As in selling anything, the best sale is made on a clean nonentangling basis. That is, when an item or service is sold it must be sold on a complete package deal. As it is now, the lack of attention paid to the waste disposal problem puts a tremendous block to normal industrial sale and usage.

We receive inquiries regularly from customers ranging from the very small users of tracer amounts of radioisotopes to power generator reactor operators. These people are asking for help with waste disposal. Some of them are brought very abruptly to face the fact that without this answer they cannot start their process. We, in turn, must tell these people very factually that as of this minute the waste disposal problem is in the process of evolution.

Last July our company made several strong representations to the AEC asking for land site operations regarding low level waste disposal. The ocean disposal system had very obviously given rise to a tremendous host of conflicting feelings. These feelings were represented by fish and game clubs, wildlife protective associations, commercial fishing organizations, State public health boards, etc. Add to this the great murmur of the general public and it would seem that our ocean disposal program, regardless of its technical soundness, will be, and is now, hamstrung by public pressures. This leaves us with a very obvious place to turn—and that is land areas.

We have now in the United States sites which are under the control of the Atomic Energy Commission. These sites are to a more or less degree contaminated with radioactivity. They are the center of skilled technical ability in controlling and handling radioactive materials. It seems obvious that these represent an immediate answer to our low-level waste problems. It is encouraging to note that on January 28 the Atomic Energy Commission issued a news release saying that sites were being made available. It is our hope that this will be translated to a working procedure before too long.

Our company is a waste handler. Consequently, we are dramatically aware of the great importance that this little-studied problem has on the effect of the total atomic industry program. It would be our hope that the Commission would encourage a complete national study of low-level waste to produce an actual catalog of these materials by location, isotope, and physical state. This would then be integrated into a handling problem which could be met by using cur-

rently established atomic energy sites. This would give a great boost to industrial utilization of radioisotopes. It would enable customers such as ourselves to go out and sell radioisotopes on a complete package deal. We could tell our customers that the waste handling problem is under control and has a definite procedural setup whereby their waste can be handled.

It is our hope that this Joint Committee will consider establishing a special task force to first bring the low-level waste disposal problem into sharp, clear focus, and then to make sure that proper procedures are set up to utilize existing AEC sites for orderly disposal of these low-level wastes.

It goes without saying, of course, that the same program must hold true for high-level waste.

The growth of radioisotopes in industry has been slow and at times discouraging. However, we feel that this technology will become an established part of America's industrial picture. It will call for a very hard selling job. It will require a complete knowledge of all the problems attending the sale and application of radioisotopes. Particular emphasis placed on any one highlight will cause trouble, inasmuch as the total picture is often different from any highlight featured in a popular magazine, article, or speech. It is obvious that there is no magical formula to produce the success, or it would have been found by the otherwise very successful large companies already working in this field.

Industry is no different in its attitude toward radioisotopes than it is toward electronics, hydraulics, or mechanics. Industry must have a reason to buy radioisotopes. This reason requires increased efficiency over existing means. Industry cannot, and will rarely, be bothered with the problems associated with utilization of radioisotopes. These problems are for us, the producing industry, to iron out. A realistic attitude on our part will clearly indicate that our approach must be scaled to the size of the problem, the potential market, and the state of the art. These factors become hard taskmasters but they will keep our program in line.

There are a few areas in which the Commission might help by reducing their direct competition with industry. When we meet these situations we take the matter up with the Commission. In every case we are most happy to report a most cooperative attitude. We hope this will result in action. The members of the Commission are always extremely helpful. They have a tough job. They must push the use of radioisotopes. They must regulate the use of radioisotopes. I think they are doing a darned good job in this most difficult feat of pushing and pulling on the same rope.

We can't come up with any button to push in order to solve all the problems; we don't expect to. We expect to make progress by steady work in understanding the application of radioisotopes to industrial problems.

Addendum to Statement

Additional Detail Data Concerning Low-Level Waste Disposal

It might be of interest to follow up our preliminary general statement of February 17, 1960, with additional details concerning our actual experience with problems involved in handling low-level waste materials.

We can start with our initial contract with the Air Force. This was awarded on August 18, 1958, and provided for the payment of $4.99 per cubic foot for our handling their radioactive waste. This contract begot a whole series of very costly events. It is true that at the time the contract was let the current exact specifications covering waste disposal were not set. Thus, we were faced with a changing picture which involved continuous discussions regarding actual dump sites, packaging specifications, etc. Along with this there occurred a continuing series of difficulties with shipments which resulted in a very poor operation from an economic point of view. One illustration of this was a shipment of about 3,700 cubic feet, made up of 58,000 pounds, of miscellaneous contaminated metal-alloy beams, boxes, ovens, and other structural members. This arrived in an open-truck condition. It was not packaged in containers. The particular alloys involved were extremely hard and required the expenditure of many cylinders of cutting gas and time in cutting them up for disposal. The entire processing job produced 250 barrels of waste. Based on the contract payment rate, this was an equivalent payment of $7.40 per barrel. Later on we will point out that an estimated minimum charge of $22 per barrel seems about the best one could do with extremely low-level waste. Hence, this particular operation resulted in a substantial loss. I might point out, however, that the

Air Force did provide additional payment for the direct out-of-pocket costs involved in cutting up and unloading this material.

In yet another case involved in the same contract, we received notification of a rail car of waste stored at our local Southern Pacific freight office. We were informed that this car could not be released before demurrage was paid. In checking with our local Air Force contracting officer, it was requested that we provide the demurrage charge. Accordingly, we wrote out our own company check and had it delivered in person in order to get the car released. In the car were 11 very small drums of radioactive material, which weighed exactly 1,183 pounds. The freight handlers were all worked up about the radioactive nature of the car and were all the more taken aback at the few small paint drums that were in the car.

Another incident, and one that is still in the claiming process, involved our receipt of a quantity of radioactive waste under a Government bill of lading. This material was received by us without prior notification, and accordingly we contacted the local Air Force office as to disposition. We received a request to prepare this shipment for retransportation to another waste-disposal concern in New Jersey. Naturally, we were quite interested in this procedure whereby a load of radioactive waste went from Texas to Los Angeles, and now was going back to New Jersey. However, we complied with the Air Force request. In order to do this we had to handle the material using proper safety procedures. In this process we accumulated modest costs for the unloading, reloading, storage, and general safety precautions involved with this material. We requested payment of $400 to cover the total job from the Air Force, and this was promptly rejected because we did not have prior authority to do the work. This is still in the discussion stage. Perhaps the most confusing part of the whole contract was a supplemental agreement we received, properly signed by the contracting officer, increasing the payment from $4.99 to $6.50 per cubic foot. This, we thought, was probably brought about by other contractors who got into the picture during a later stage, and accordingly asked for a change in pricing. We very happily signed this supplemental agreement, sent it back to the Air Force base, and in due time received our countersigned copies for our files. Shortly thereafter, however, we received another amendment pointing out that the supplemental agreement which we had previously signed increasing the rate contained a "scrivener's error" and consequently was to be ignored. We know of many cases in which contractors made "scrivener's errors," but such errors seem to be contractors' liabilities.

This experience picture clearly shows the complexities of the problems involved in handling waste material. It must be kept in mind that this contract was probably a new experience for the particular Air Force group involved, hence the many problems. Unfortunately, these problems cost us direct money.

The actual details of handling the waste will also help to clarify the picture. To begin with, as you know there are four basic types of emissions—alpha, beta, gamma, neutron—and a fifth class which is a "duke's" mixture. The physical condition of the material presents the next big variable, and this is extreme indeed. It can range from liquids to gases, and quite often includes odd-shaped articles such as large aircraft tires, I-beams, structural materials, etc. The energy level and specific activity of the waste is still another factor that must be taken into consideration. We begin the packaging operation with a set of well-defined current specifications. The activity level, for example, cannot exceed 200 milliroentgens at the surface or 10 milliroentgens per hour 1 meter from the surface. In using a 55-gallon drum, heavy duty (18-gage steel must be used), the drum must be tight, must weigh 550 pounds minimum, and in our case is to be reinforced with specified reinforcing bars. These are not exclusive requirements as there are other specifications pertaining to the packaging.

One set of cost calculations indicates that a minimum of $25 is required to produce such a minimum activity drum ready for dumping. It must be pointed out that these costs refer to ideal conditions in which solid, rather dense, and low energy beta wastes are concerned. There can be quite a range of figures quoted to come up with typical drum prices. However, there are certain basic costs of material and time. To these must be added overhead and a profit factor. These latter two vary widely from company to company.

In order to produce the maximum allowable readings at the drum surface, we must hold the contained radioactivity to perhaps a few millicuries of gamma emitters. This would mean that 1 curie of high energy gamma waste would result in 500 drums of packaged waste. This is a cost of $12,500 to package

1 curie of gamma emitter based on a $25 per drum cost. Again, we must say that these are typical figures and will be subject to some modification. Our experience in handling odd-shaped wastes requiring encasement in concrete shows that the costs go up much higher than those for drummed materials. We have had one case, for example, where in order to handle a long object of approximately 2.2 cubic feet we had to prepare a 3 cubic foot concrete coffin. This had to be poured in place and required $227 worth of direct time and material. This produced an out-of-pocket cost of approximately $110 per cubic foot. There is always a question in handling odd-shaped objects as to whether they should be encased in concrete in a form or cut up. Our experience to date has indicated that encasement in concrete is the safest procedure. Each unusual shape requires specific AEC approval and this, too, requires time.

All the discussion thus far is centered about the trials and tribulations of the radioactive waste handler. The figures indicate the general cost areas that must be applied if a profit is to be made in handling radioactive waste. Relatively low level material can be packaged in a drum at a cost in the neighborhood of $25 to $35 for a few millicuries of waste. Again, the physical form of the waste is often as important as the activity. For example, a major oil company involved in a piston-ring experiment may produce 100 barrels of contaminated oil per year. There might be only a few microcuries per barrel, but the problem of converting this lighter-than-water material to a sinkable waste produces an indicated cost of up to $150 per drum. Thus, the cost of running a piston-ring experiment might be in the neighborhood of $15,000 for the waste disposal alone. It is quite probable that this particular waste might better be handled by incineration, etc., but the $15,000 figure remains as a ballpark figure for handling it under current ocean disposal criteria.

It is quite evident that the cost of handling waste products can be a significant factor in calculating the overall benefits to isotope users. In many cases isotope users can save considerable expense by doing a lot of the pretreating and prepackaging themselves. Many handlers will charge on a combination volume-weight-activity basis. The user should be aware of all the pricing factors in order to provide the waste-product handler with the most economic package from the user point of view. These problems may sound quite complex, but we feel they are only so because probably the attention paid to them was not quite in proportion to the main isotope use studies. We feel sure that continued AEC cooperation in developing landsites and additional ocean-disposal criteria will solve the problem for the benefit of all radioisotope users.

It has been pointed out that the AEC budget for developing industrial usages of radioisotopes is quite minute compared with the huge outlays for reactors. By the same token, our waste-disposal efforts have been equally minute in dollar expenditures versus the major reactor programs.

Despite this, the "trouble" factor produced by waste-disposal problems is just as large as any other, hence it deserves major league attention.

Respectfully submitted.

A. A. MICHAUD,
Vice President, Nuclear Corporation of America, Isotopes Specialties Co. Division.

NUCLEAR ENERGY LIABILITY INSURANCE ASSOCIATION,
New York, N.Y., February 12, 1960.

Hon. CLINTON P. ANDERSON,
U.S. Senator from New Mexico,
Chairman of the Joint Committee on Atomic Energy,
Washington, D.C.

MY DEAR SENATOR: Mr. Hubert Yount, executive vice president of the Liberty Mutual Insurance Co., has informed me that you have suggested in a letter to him dated January 7, 1960, that it might be advisable for the nuclear-liability-insurance pools to make known to the Joint Committee at the 202 hearings their concern with the fact that insignificant amounts of their capacity are being employed. Accordingly, I am enclosing for inclusion in the record of the hearings on the development, growth, and state of the atomic energy industry which begin on February 16, 1960, a copy of statements which were submitted to the U.S. Atomic Energy Commission by the following pool representatives:

1. Hubert W. Yount, executive vice president, Liberty Mutual Insurance Co., Boston, Mass.;

2. Manning W. Heard, executive vice president, Hartford Accident & Indemnity Co., Hartford, Conn.;
3. Charles J. Haugh, vice president of the Travelers Indemnity Co., Hartford, Conn.;
4. Guy E. Mann, senior vice president of the Aetna Casualty & Surety Co., Hartford, Conn.;
5. J. Dewey Dorsett, general manager, Nuclear Energy Liability Insurance Association, New York City, N.Y.

These statements were delivered on January 19, 1960, at a meeting with Commissioners Floberg and Graham, General Manager Luedecke, and other members of the Commission staff.

Representatives of NELIA will be more than happy to be present at the hearings on any day you might select to answer any questions that might occur to you or other members of the Joint Committee or to provide additional details supplementing the enclosed statements.

Ten additional copies of the statements will be mailed to you at the offices of the Joint Committee on Atomic Energy.

Most sincerely,

J. DEWEY DORSETT,
General Manager.

STATEMENT SUBMITTED BY HUBERT W. YOUNT, EXECUTIVE VICE PRESIDENT, LIBERTY MUTUAL INSURANCE CO., BOSTON, MASS., TO U.S. ATOMIC ENERGY COMMISSION ON JANUARY 19, 1960

PRIVATE INSURANCE AND THE FINANCIAL PROTECTION REQUIREMENTS OF THE ATOMIC ENERGY ACT OF 1954, AS AMENDED

My name is Hubert W. Yount, executive vice president, Liberty Mutual Insurance Co., Boston, Mass. I am also chairman of the underwriting committee of the Mutual Atomic Energy Reinsurance Pool. In order to understand the position and objectives of our industry, I will state briefly what our American insurance companies, stock and mutual, have done since the enactment of the Atomic Energy Act of 1954. This has required a major effort to put our companies in a position to provide the insurance service and protection which we were told would be required by persons operating nuclear facilities or furnishing services to such facilities and were necessary for the protection of the public.

Five years ago the Atomic Energy Commission appointed a group of insurance executives to study the insurance problems which would result from private industrial participation in the new program. We respectfully refer you to the first and second reports made to the Commission by the group.[1] After deciding that the hazards were insurable and that an intensive program of loss prevention and inspection service was imperative, the members of this group took the lead within the respective segments of the industry in developing a broad program of insurance coverage and service.

The first step was the organization of three pools, or syndicates, to write insurance for nuclear facilities. By June 1956, these three pools—Nuclear Energy Liability Insurance Association (NELIA) Nuclear Energy Property Insurance Association (NEPIA), and Mutual Atomic Energy Reinsurance Pool (MAERP)—through their more than 300 member companies in the United States and worldwide participation of foreign reinsurers, had marshaled for any one location an aggregate underwriting capacity in excess of $125 million. Of this capacity, the largest amount ever before offered in the worldwide history of insurance, $60 million was made available for nuclear energy liability insurance, $46,500,000 from NELIA and $13,500,000 from the mutual companies, through a primary underwriting syndicate, Mutual Atomic Energy Liability Underwriters (MAELU) which is in turn reinsured by the Mutual Pool (MAERP).

Having developed maximum insurance capacity, a second problem was that of the coverage which would be provided. Because the insurance capacity developed was believed insufficient to meet the losses which might result from a major nuclear catastrophe, Government indemnity was finally provided under the Price-Anderson Act after nearly 2 years of hearings and discussions. During the past 3½ years, representatives of NELIA and MAELU have worked

[1] AEC release No. 662, dated July 13, 1955; AEC release No. 796, dated Mar. 19, 1956.

with the staff of the Commission, with the Joint Committee of the Congress, and with the atomic energy industry in a cooperative effort to develop a sound nuclear energy liability insurance program supplemented by a sound Government indemnity program. These programs have been designed primarily for the protection of the public but also give the protection needed by those directly engaged in the atomic energy industry.

As a result of this effort, the operator of a nuclear facility can now buy a nuclear energy liability policy facility form which is not only the broadest liability insurance contract ever written in the United States and elsewhere but also provides more capacity than any previously written. The amount of protection offered is a maximum of $60 million. The policy covers, first, any person or organization (except the United States or any of its agencies) legally responsible for the occurrence of a nuclear incident arising out of the operation of the insured facility is an insured under the policy. Second, the policy covers damage to property of an insured which is away from an insured facility. Third, the policy protects an employer or his workmen's compensation carrier against loss by reason of injuries to his employees who are employed away from the facility. The policy is not written for a limited term, but rather remains in effect from its effective date until terminated in accordance with its terms. In this connection see insuring agreements I, II, and IV of the policy, a copy of which is attached to this memorandum.

A third major problem has been the development of a specialized loss-prevention and inspection service which we have regarded as an absolute requirement for the protection of the public, the Government, and of our own companies. Casualty insurance is not satisfied merely with payment or indemnity but regards the prevention of losses as one if its more important functions. In that connection it has been dealing with radiation sources and radiation injuries since the turn of the century. Since 1954 the casualty companies have employed or trained a number of health physicists and other engineers in nuclear problems. They have also trained other engineers in radiation detection and safety. As a result, NELIA and MAELU are giving operators of insured nuclear facilities an inspection and loss-prevention service that they would find difficult, if not impossible, to get anywhere else. In addition, NEPIA and MAERP inspectors on the physical damage problems of nuclear insurance are also trained in safe operation and in the protection of the property of the facility. All of these inspectors work with facility operators to prevent damage to facilities, injuries to employees and to the persons and property of the public. They cooperate with the Commission in enforcing its safety regulations. These services are today a normal part of the insurance business which long ago abandoned the concept that mere indemnity for a loss sustained is an adequate answer to the perils incident to modern industrial operations.

A fourth problem has been the organization and mobilization of our casualty industry experience and personnel to handle the special types of claims resulting from nuclear hazards. Through their member companies, NELIA and MAELU have available for their policyholders the services of thousands of skilled field claimsmen now working in insurance company offices throughout the United States. Within a few hours after receipt of notice of an incident either NELIA or MAELU will have claimsmen at the scene to start investigation into the cause of the accident and the extent of any resulting injury to persons or property. NELIA and MAELU have together perfected plans for the investigation and handling of claims resulting from a nuclear disaster. In cooperation with members of the staff of the Commission they are working on the preparation of a list of physicians and hospitals qualified to treat persons suffering from radiation injuiries. They are likewise compiling a list of qualified nuclear physicists and other experts whose services will be valuable in connection with the investigaton of a nuclear incident, the decontamination of property and other technical problems which will follow such an occurrence.

In the investigation and handling of claims and defense of suits resulting from a nuclear incident, the work of field claimsmen will be supervised and guided by experienced claimsmen and lawyers on the home office staffs of the member companies of NELIA and MAELU. Some of those companies have given selected members of their home office departments special training to fit them to deal with the peculiar problems they will meet in supervising the investigation and handling of claims and suits resulting from nuclear incidents.

The technical services above described, which the policyholders of MAELU and NELIA will receive, are not ordinarily for sale as such. They parallel the serv-

ices given by a casualty insurer to its industrial risk policyholders. Such services are part of the modern concept of insurance which includes not only the acceptance of risk of loss, but the prevention and control of loss and the spreading of the cost of service and losses over as wide a base as possible.

This principle of insurance spread would be violated if the Commission should fail to require any financial protection as proposed with respect to certain projects or should require inadequate financial protection as respects other projects. What is perhaps of even more importance, however, is the implied willingness to sacrifice public protection through the prevention of loss. Indemnification after a loss is a poor substitute for the prevention of loss to the extent that the services described above can prevent or minimize losses. It should not be necessary to subsidize the cost of necessary services on nuclear hazards from other business. It is only equitable that such exposures should provide through a broad premium base adequate income to maintain a proper standard of service. This cannot be accomplished unless the Commission applies broadly and equitably the requirements for financial protection.

A fifth problem has been that of pricing and premium determination for nuclear liability insurance coverage and service. The aggregate of the premiums for any kind of insurance must be an amount sufficient to cover losses and expenses, plus a margin for profit and contingencies. Over the years the cost of any kind of insurance is determined by experience. In most lines of property and casualty insurance, underwriters, from analysis of past premiums and losses, with due consideration to present trends and changing times, can determine with reasonable accuracy the losses and expenses which will be incurred on business written.

Such a determination is not possible with respect to nuclear energy liability insurance. The nuclear arts are still new, changing, experimental. There is no past experience on which to base premiums. Moreover, there is present a risk, remote but nevertheless real, that a catastrophe costing many millions of dollars will occur. Hence, the problem facing NELIA and MAELU was to develop a premium plan which would produce the funds necessary (1) to pay expenses other than loss expenses, (2) to pay for ordinary losses and loss expenses, and (3) to permit the accumulation of a reserve for catastrophe losses, and which would, over a period of years, if there were no catastrophe losses, result in the losses and expenses actually incurred by the insurers determining the final premiums paid by those persons engaged in the atomic energy industry.

The industry credit rating plan adopted by NELIA and MAELU meets the requirements above outlined. The initial premium charged an insured for nuclear energy liability insurance is a provisional premium. A proportion of every provisional premium received is set aside in a reserve fund. That proportion ranges from 67 percent on small risks to a maximum of 75 percent on large risks. The funds so accumulated will be used only for the payment of losses and loss expenses and for return premiums on cancellations for a period of 10 years. During the 11th year, if the losses and loss expenses incurred, including reserves for unpaid losses and loss expenses, during the 10-year period are less than the total aggregate deposits in the reserve fund for the 10-year period, a refund will be made to first-year policyholders. To illustrate, assume that at the end of 10 years there is in the reserve fund a balance of $10 million, after deducting losses and loss expenses incurred. Assume further that the provisional premiums paid the first year were 2 percent of the aggregate 10-year provisional premiums. Two percent of the reserve fund balance, or $200,000, would be distributed ratably among the first-year insureds. This procedure will be repeated annually so long as the rating plan remains in effect. In the event unfavorable loss experience makes impossible a refund for any year, the provisional premium paid by each insured for that year becomes the final premium for that year. If and when the rating plan is terminated, any amount remaining in the reserve fund will be disbursed in accordance with the provisions of the plan, or in other words will be used for the payment of losses and loss expenses or for refunds to insureds. In short, the rating plan so operates that it is certain that approximately 70 percent of the provisional premiums paid to NELIA and MAELU on nuclear energy liability insurance will be used to pay losses and loss expenses or returned to the purchaser of such insurance. If the aggregate of losses and loss expenses exceed the aggregate amount allocated to the reserve fund, the members of NELIA and MAELU and their reinsurers stand the loss.

Admittedly, today no one knows whether the provisional premiums established by the rating bureaus for facilities insured by MAELU and NELIA are

reasonable and adequate, too low or too high. Only the experience of a number of years will answer those questions. One fact is certain, however, and that is that the industry credit rating plan will so operate that the ultimate cost of nuclear energy liability insurance will be reasonable. Furthermore, it should be noted in passing that the development expenses of the nuclear program to our casualty companies to date reflecting the time and travel of salaried personnel—legal, underwriting, loss prevention, claim, actuarial, and other technical people—cannot possibly be recouped in the foreseeable future through the company expense allowances in our nuclear liability insurance premium income.

To conclude, the members of NELIA and MAELU at substantial expense, have placed themselves in the position to act as a supplier to the atomic energy industry—a supplier, first, of broad insurance protection and second, of needed loss prevention, claims, and legal services. Both facets of this program are essential to the atomic energy industry and to the public. The development expenses in building this program have been comparable to those of other segments of industry active in the nuclear energy field. The casualty insurance industry undertook the program I have described at the request, I should say the urging, of the Joint Committee of the Congress and of the Atomic Energy Commission. We submit the Government should not usurp a field in which private industry is not only ready and willing to perform at reasonable cost but to provide services not otherwise available for the protection of the public.

STATEMENT SUBMITTED BY MANNING W. HEARD, EXECUTIVE VICE PRESIDENT, HARTORD ACCIDENT & INDEMNITY CO., HARTFORD, CONN., TO U.S. ATOMIC ENERGY COMMISSION ON JANUARY 19, 1960

PRESENT POSITION OF THE INSURANCE INDUSTRY IN THE ATOMIC ENERGY PROGRAM

My name is Manning W. Heard and I am executive vice president of the Hartford Accident & Indemnity Co., of Hartford, Conn.

Having just heard from Mr. Yount the history of the extensive nuclear energy insurance facilities created by the insurance industry, stock and mutual, at the urging and request of the Congress and the Atomic Energy Commission, may we describe the position in which the insurance industry now finds itself.

We feel that we are being denied a significant part in the development and utilization of atomic energy for peaceful purposes.

And yet we find congressional and executive expressions of governmental policy clearly indicating that the insurance industry, like other private enterprise, should be invited to play an important part in the growth and development of the atomic industry.

The policy of the United States with respect to the position of private enterprise—in which insurance plays a vital part—was clearly enunciated in section 1 of the original Atomic Energy Act of 1954 wherein it was declared that a purpose of that act was to "strengthen free competition in private enterprise."[1]

The concept of teamwork between government and industry is woven into the legislative history of the original Atomic Energy Act of 1954. May we quote from Senate Report No. 1699 accompanying that act:

"We do not believe that the efforts of free enterprise, using its own resources and moneys, are by themselves adequate to achieve the speediest possible attack on the goal of peacetime power. Neither do we believe that maximum progress toward this objective will be afforded by an effort relying exclusively on governmental research and development, using the public's moneys. We believe, rather, that teamwork between government and industry—teamwork of the type encouraged by these amendments—is the key to optimum progress, efficiency, and economy in this area of atomic endeavor." (U.S. Code Congressional and Administrative News, 83d Cong., 2d sess., 1954, p. 3464.)

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[1] "SECTION 1. Declaration:

"Atomic energy is capable of application for peaceful as well as military purposes. It is therefore declared to be the policy of the United States that—

"b. The development, use, and control of atomic energy shall be directed so as to promote world peace, improve the general welfare, increase the standard of living, and strengthen free competition in private enterprise.

"The Atomic Energy Act of 1954 containing this declaration of policy was adopted by both Houses of Congress by votes which included a majority of both parties." (Atomic Ind. Reporter, 203: 4.)

It is the present state of this teamwork between government and the insurance industry which brings us before you today.

After the passage of the original Atomic Energy Act of 1954, it became apparent that the atomic industry's inability to secure adequate financial protection against the risk of unprecedented liability was threatening the national objective.[2]

On March 25, 1957, the Chairman of the Atomic Energy Commission at hearings held by the Joint Committee on Atomic Energy highlighted that the lack of adequate protection against liability was one of the major obstacles to atomic energy development.[3]

To remove this major obstacle, steps were taken to amend the Atomic Energy Act of 1954. On September 2, 1957, the President approved Public Law 85–256 (71 Stat. 576) and therein we find a clear expression of congressional and executive intent to the effect that U.S. funds may be made available not for all but for a portion of the damages suffered by the public from nuclear incidents.[4]

We emphasize that the Congress declared that "the United States may make funds available for *a portion* of the damages" because it is our position before you today that an administrative pattern has arisen which in the license program has made United States funds and resources needlessly paramount to those available from private insurance industry and, in the contractor program, administrative action has excluded private insurance almost entirely.

Both, we submit, are inconsistent with the findings and statement of policy of the Congress of the United States.

Sections 170b and 170g were enacted in 1957 to carry out the governmental policy of using "to the maximum extent practicable, the facilities and services of private insurance organizations."[5]

In reference to these sections, it is of real interest to note the following comments contained in Senate Report No. 296 (85th Cong., 1st sess.):

In reference to 170b:

"One point of caution should be mentioned. The reference to the cost of insurance in this subsection is not intended to encourage the Commission to undercut the amounts of private insurance provided at reasonable rates." (S. Rept. No. 296 at p. 20.)

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[2] "To the extent that private industry is unable to secure adequate financial protection against the risk of unprecedented liability and is consequently reluctant to proceed without such protection, the achievement of a major national objective is threatened." ("Columbia University Legislative Fund, Financial Protection Against Atomic Hazards" January 1957) (prepared as an independent research project for Atomic Industrial Forum, Inc.), p. 1.)

[3] "The advocacy of the atomic energy industry for protection against liability certainly has not lessened since last year. A few indications supporting this conclusion can be found in the statements made by members of the industry at a meeting of the Atomic Industrial Forum on this subject on Jan. 22, by the forum's report on "Financial Protection Against Atomic Hazards,' by the forum's poll of its members which indicated that lack of adequate protection against liability was one of the major obstacles to atomic energy development, and by the consensus expressed at the recent meeting of the American Management Association." (P. 3, statement by Lewis L. Strauss, "Insurance and Indemnity Legislation.")

[4] "SEC. 2. Findings:

"The Congress of the United States hereby makes the following findings concerning the development, use, and control of atomic energy:

"1. In order to protect the public and to encourage the development of the atomic energy industry, in the interest of the general welfare and of the common defense and security, the United States may make funds available for *a portion* of the damages suffered by the public from nuclear incidents, and may limit the liability of those persons liable for such losses." [Emphasis supplied.]

[5] "170b. The amount of financial protection required shall be the amount of liability insurance available from private sources, except that the Commission may establish a lesser amount on the basis of criteria set forth in writing, which it may revise from time to time, taking into consideration such factors as the following: (1) the cost and terms of private insurance, (2) the type, size, and location of the licensed activity and other factors pertaining to the hazard, and (3) the nature and purpose of the licensed activity: *Provided*, That for facilities designed for producing substantial amounts of electricity and having a rated capacity of 100,000 electrical kilowatts or more, the amount of financial protection required shall be the maximum amount available from private sources. Such financial protection may include private insurance, private contractual indemnities, self insurance, other proof of financial responsibility, or a combination of such measures."

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"170g. In administering the provisions of this section, the Commission shall use, to the maximum extent practicable, the facilities and services of private insurance organizations, and the Commission may contract to pay a reasonable compensation for such services. Any contract made under the provisions of this subsection may be made without regard to the provisions of sec. 3709 of the Revised Statutes, as amended, upon a showing by the Commission that advertising is not reasonably practicable and advance payments may be made."

In reference to 170g:

"Subsection g requires the Commission to use to the greatest extent practicable the facilities and services of private insurance organizations. Under the bill, as drafted, the Commission is authorized to use the services of those organizations which could provide real services to the Commission without requiring the Commission to build up an organization of its own. (S. Rept. No. 296 at p. 23.)

These are congressional expressions of governmental policy, but the Congress has not been alone. As recently as September 21, 1959, the Executive Office of the President, Bureau of the Budget, stated in Bulletin No. 60–2 that:

"2. *Policy.*—It is the general policy of the administration that the Federal Government will not start or carry on any commercial-industrial activity to provide a service or product for its own use if such product or service can be procured from private enterprise through ordinary business channels."

To summarize this background of congressional and executive policy—but, unfortunately, not administrative implementation—may we quote from the report of Columbia University's "Financial Protection Against Atomic Hazards" (p. 46):

"There is general agreement that whatever Government program is adopted, insurance or indemnity, there should be room for the activity of private insurers, and that the Government should not cover liability from the ground up. Total Government indemnity would be at odds with the intent expressed in the 1954 act to develop atomic energy within the framework of private enterprise where consistent with overall objectives. Furthermore, such action would be contrary to the practice which the Government has generally followed in other insurance programs. Where the Government has entered an area of possible conflict with private insurance, its entry has usually been conditioned on the nonavailability of insurance in the private market."

With the door thus opened for the insurance industry to play its part in the promotion of the peaceful use of atomic energy, what did it do? What teamwork did it offer?

Private insurance industry, stock and mutual, did this:

1. It created, administered, and financed the stock and mutual nuclear energy liability insurance pools (NELIA and MAELU) and amassed the unprecedented liability capacity of some $60 million which is presently available.

2. It assumed, under standard policies, the new and unknown burden of the nuclear energy hazard in workmen's compensation insurance.

3. It assumed, under standard policies, the new and undefined hazards arising out of the use of commercial radioactive isotopes.

We are not here memely to sell insurance nor do we suggest that administrative regulations be biased on our behalf; but we would be less than frank if we did not insist that the insurance industry be treated before the Commission on a parity with all other private industry pursuant to expressed congressional and executive policy.

The insurance business is, in a very real sense, the trustee of the public's money. The very concept of insurance is to collect premiums from the many and pay claims to the few, and when administrative action needlessly restricts the use of private insurance and its underwriting capacity, it undermines and prejudices the validity of the insurance concept. The nuclear liability pools cannot insure just a few risks without violating the fundamental premise of insurance that there be a fair spread of risk.

If, by administrative action, the insurance industry is denied such fair spread of risk and if, after it has created vast insurance capacity at the request of the Congress and the Commission, only a small part of that capacity is used because of administrative action, then the insurance position of our industry becomes untenable.

Administratively, we are being denied the climate in which we can live in:

1. The licensee program, which will be discussed later, wherein limits of financial protection, and hence the area to be insured, have been proposed at levels so low that it would scarcely cover the injuries to a few people; and

2. The contractor program, which also will be discussed later, wherein private insurance has been completely bypassed in favor of governmental indemnity, for example, in the power demonstration reactor program at Shippingport.

We submit not that the insurance industry be specially favored but only that it not be excluded from what we view as our legislated right to participate in the future of atomic energy development on a reasonably sound insurance basis. We believe this to be in the public interest.

STATEMENT SUBMITTED BY CHARLES J. HAUGH, VICE PRESIDENT, TRAVELERS INDEMNITY CO.

My name is Charles J. Haugh and I am a vice president of the Travelers Indemnity Co.

The memorandum that Mr. Dorsett submitted with his letter of November 20, 1959, to Chairman McCone points out that the method of determining amounts of financial protection proposed by the Commission has little relation to hazard. There are three things that strike me forcibly in this connection.

The first, of course, is the small amounts of financial protection the regulations would call for in many instances.

The second is the insurance limits purchased by those who work with nuclear material, but who do not quailfy for Government indemnity.

The last is the expressions in the record about the unlikelihood of the indemnity ever coming into play.

Taking the points in order, let me cite a few examples of required financial protection.

A 1-MW research reactor located anywhere must furnish $1,500,000 of financial protection as against available insurance of $60 million. Now, I am not talking about the probability of an incident, but rather what could happen if it did occur. I suspect that a maximum credible incident in such a reactor in a thickly populated area could cause great injury to persons and property and the resulting costs might even exceed $60 million. I recognize that all this does not leave the public without a means of recovery, but it is also clear to me that Government indemnity is being injected as the source of that recovery in preference to insurance available from the liability pools.

Similar illustrations can be drawn for a variety of situations, up to the point where the proposed regulations intersect the statutory requirement of maximum available insurance. For brevity, I offer only two. A 20-MW test reactor in a medium population location would have to provide $3,900,000 of financial protection, and a 50-MW power reactor in a low population area would have to provide $7,500,000 of financial protection. These figures are not realistic in terms of potential hazard, and one byproduct of this is that Government funds from the indemnity are needlessly exposed in an area where the insurance industry stands ready to perform.

Would reactor operators be content with insurance limits of this order if Government indemnity were not present and they were making their own independent appraisal of hazard? We think not, for two reasons. First, limits of $10 million or more are frequently found in fields having nothing to do with the nuclear energy hazard. Second, there are concrete examples right in NELIA and MAELU.

Chemical concerns and fuel fabricators working with appreciable quantities of clean cold special nuclear material do not come under the indemnity at this time. To my knowledge, the 2 pools are presently insuring 19 such risks, and the limits they have bought are:

1 risk at	$2,000,000
2 risks at	3,000,000
5 risks at	5,000,000
5 risks at	10,000,000
2 risks at	15,000,000
1 risk at	15,500,000
2 risks at	20,000,000
1 risk at	60,000,000
Total (19)	[1] 12,000,000

[1] Average limit.

If the study the Commission is making of the need for application of indemnity to fuel fabrication shows that it should be extended to these operations, will the level of financial protection be set low so that another segment of the market for insurance will be stripped away?

The early record is replete with indications that the indemnity was thought of as a last resort and not as a regular working tool in otherwise insurable areas.

Before the Joint Committee hearings in 1956 on governmental indemnity Senator Anderson sent an open letter to interested parties. Among other things he said (p. 2 of the record):

"2. We need information on the range of rates to be charged by the private insurance industry. We recognize that this is difficult for the newly organized syndicates. But Congress must know whether private reactor operators and equipment manufacturers are going to be able to afford private insurance—*otherwise the Government indemnity might extend downward to an unreasonable extent.* 'We can't buy a pig in a poke.'" [Emphasis added.]

In the same 1956 hearings I find a colloquy between Representative Cole and Chairman Strauss (p. 7 of the record) speculating on possible increase in private insurance capacity in future years. Hope was expressed that this would come about with the accumulation of knowledge and experience. I submit, gentlemen, that if the present stifling climate is continued, there is a greater chance of insurance capacity shrinking than expanding. There will not be what we call a book of business to support the occasional heavy exposure of assets on the largest reactors.

The May 9, 1957, report of the Joint Committee to Congress has a reference on page 9 to the anticipation of the committee that "there never will be any call on the fund for payments * * *" and on page 20 of the same report the following appears in the discussion of section 170b:

"One point of caution should be mentioned. *The reference to the cost of insurance in this subsection is not intended to encourage the Commission to undercut the amounts of private insurance provided at reasonable rates.* Since the program is so new, and no experience as to the rates established the Commission must be in a position to set the amount of financial protection required at an amount lower than amount of private insurance offered *if the rates appear high* and all other factors indicate a lower amount is appropriate." [Emphasis added.]

To the best of my knowledge the Commission has not expressed the opinion that the prices and rating systems employed by the liability insurance pools produce unreasonable rates. This is understandable in that any loss and loss expense dollars not actually used for their intended purpose will be returned to customers through the operation of the long-term rating plan.

Finally, I turn to the speech Senator Anderson made in the Senate on August 16, 1957, when the bill that became Public Law 85–256 was passed. One sentence reads:

"The best estimate of all who are concerned with the field is that the Government will probably never have to make any payments under this statute."

This does not sound to me like a man who was thinking in terms of $1,500,000 of financial protection for a 1-MW reactor or $3,900,000 to $7,500,000 for good-sized test and power reactors.

I should say here that I feel just as strongly as the previous speakers about the right of the insurance industry as a segment of private enterprise to perform where it can do so. I also know that they join with me in the feeling that when we find the Government moving into our house, criticism is not our sole function. We should record our objections and we are doing that here. We recognize an equal obligation to say what we think is equitable.

With that in mind, let me make some more detailed points on the proposed regulation.

In our opinion, the items of power level and population proposed by the Commission are reasonable as a means of establishing amounts of financial protection for reactors. A population index can be unsatisfactory as a measure of property values, but we do not have an alternative to propose that would recognize property values in a numerical formula.

Consequently, our quarrel is not with the items as such, but rather with the manner in which the Commission proposes to employ them.

For power level the original straight line approach of $150 per KW is retained so that financial protection proceeds in even steps from the minimum to $60 million at 400-MW thermal. It seems patent to us that since relatively small reactors can conceivably cause damage well above $60 million, failure to employ larger proportions of available insurance capacity is the substitution of indemnity for it. We recommend that the straight line be replaced by a curve that rises sharply in the lower power levels and then tapers off so as to reach total available capacity at 400-MW thermal. The curve we have in mind is based on three times the square root of the licensed power level in thermal MW multiplied by 1 million to produce an amount of financial protection prior to the application of a population factor.

Our thought on the population criteria is that the values which have been assigned to the indexes are too small. The proposed range is from 1 to 1.5 applied as a multiplier to the amount of financial protection obtained from

the power level of the reactor. Admittedly, no set of values is subject to exact statistical proof, but we just do not think that a reactor incident in a thickly populated area would produce only half again as much damage as the same incident in the middle of a desert. We recommend that the values of population indexes be revised to range from 1 to 4.

Lastly, with regard to a minimum amount of financial protection, we certainly agree that the absolute minimum of $1 million contained in the proposed regulations should be retained.

STATEMENT OF GUY E. MANN, SENIOR VICE PRESIDENT OF THE AETNA CASUALTY & SURETY CO., AT INSURANCE INDUSTRY MEETING WITH ATOMIC ENERGY COMMISSION, JANUARY 19, 1960.

My name is Guy E. Mann and I am senior vice president of the Aetna Casualty & Surety Co.

Mr. Haugh has stated our position on what we believe to be the inadequate amounts of underlying financial protection required of licensees.

We are equally disturbed that the Atomic Energy Commission has decided, in its discretion, to completely exclude private insurance against the nuclear energy hazard from the entire contractor program and to grant its contractors Government indemnity from the first dollar of liability loss.

As you know, section 170d of the Atomic Energy Act of 1954, as amended by Public Law 85–256, gives the Commission discretionary authority to require its contractors to provide financial protection and to furnish Government indemnity above the amount of financial protection required. This authority is applicable to lump-sum as well as cost-type contracts and to contracts and projects financed in whole or in part by the Commission.

We submit that the decision to give Commission contractors complete indemnity for liability claims and losses arising out of the nuclear energy hazard and thereby exclude private insurance from an area where it has demonstrated its capability to perform at reasonable cost is inconsistent with congressional intent, the policy of this administration toward private enterprise and the financial protection requred by the Commission under the licensee program. We respectfully ask that this decision be reconsidered.

In urging reconsideration, we wish to emphasize that the insurance industry is not opposed to Government indemnity for Commission contractors in the protection of the public but we do believe that indemnity should only be used to the extent that private insurance is unavailable or cannot fully fill the need.

We believe the decision of the Commission is inconsistent with congressional policy as expressed in the report from the Joint Committee on Atomic Energy, accompanying S. 2051, printed on May 9, 1957. In the section-by-section analysis, the following appears on page 21: "Subsection d authorizes the Commission to treat with its own contractors in the same way it can treat with licensees under the provisions of this bill."

The existing decision to require no financial protection of Commission contractors results in different, rather than the same, treatment of contractors and licensees. It also results in less protection to the public than is available for a comparable operation engaged in by a private licensee.

We also believe it to be inconsistent with the administration policy in that it puts the Government and public funds in direct competition with private enterprise. Bureau of the Budget Bulletin No. 60–2, issued September 21, 1959, states: "It is the general policy of the administration that the Federal Government will not start or carry on any commercial-industrial activity to provide a service or product for its own use if such product or service can be procured from private enterprise though ordinary business channels."

It further provides: "Because the private enterprise system is basic to the American economy, the general policy establishes a presumption in favor of Government procurement from commercial sources." The bulletin then goes on to recognize three compelling reasons for exceptions to this general policy. These are (1) national security, (2) relatively large and disproportionately higher costs, and (3) clear unfeasibility.

In our opinion, a more consistent program with respect to the requirement of financial protection under the contractor program would be to utilize available private insurance by requiring Commission contractors to provide financial protection in the amounts established under section 170b for licensees in every case where the activity performed by a contractor would qualify for a

license. Such a decision would place comparable activities under both the licensee and contractor programs on an equal basis so far as the protection afforded the public and the use of private insurance were concerned. It would also recognize the general policy of the Congress and the administration and the exceptions enumerated by the Budget Bureau.

The insurance industry is fully prepared to provide nuclear energy liability insurance on lal operations which would qualify for a license under existing Commission regulations and safety standards. Because of this, it seems to us that the decision to substitute indemnity for private insurance in this segment of the contractor program militates against, rather than presumes in favor of, private enterprise.

We wish to make it completely clear that we have no objection to the use of indemnity from the first dollar of loss where the contractor is engaged in operations for the Commission involving national security or hazards which would not qualify for license under existing regulations. We recognize that such activities, while involving risk of substantial loss, are justified for military or perhaps other reasons.

The nuclear insurance liability pools were formed, at the urging of the Commission and the Congress, to provide liability protection for operations which, while hazardous, were deemed to be sufficiently safe to warrant licensing by the Commission. We are, therefore, particularly disturbed that power reactors operated by Commission contractors under the power reactor demonstration program should involve no underlying insurance. Specifically, we are referring to reactors such as those at Shippingport, Piqua, Elk River, and Hallam. We see no difference between a utility operating such a reactor as a contractor and a utility operating its own licensed reactor and strongly believe that both should be subject to identical requirements as to financial protection.

The fact that the Commission owns the reactor in one case and not in the other does not affect the hazard or the need for equal protection of the public and the legitimate interests of private enterprise. General taxpayer funds should not be committed for liability claims and losses to a greater extent under the contractor program than the licensee program as long as equal private insurance coverage is available.

It seems likely that the power reactor demonstration program will be the principal vehicle by which large scale power reactors will be tested over the next few years. This likelihood is supported by the two press releases issued by the Commission on December 29, 1959, with respect to the boiling water and organic prototype reactors and the small pressurized waterpower reactor for which proposals have been received or requested. It therefore follows that exclusion of private insurance on these risks will make it impossible for the insurance industry to develop the spread of risk so essential to sound insurance operation.

In the development of the peacetime uses of nuclear energy, we, together with other segments of private industry, need broader experience. We need it so that our rating procedures and our safety engineering and claim service can be refined and perfected. This experience cannot be gained if we are to be excluded from a principal market as far as power reactors are concerned.

It is our sincere belief that the present decision should be rescinded and that the Commission should require financial protection of its contractors engaged in operations which would be eligible for licensing. We urge you not to use indemnity as a substitute for insurance but only as a supplement to available private insurance. Essentially, all we seek is that the same principles be applied to both the licensee and contractor program with respect to the use of underlying financial protection and the application of Government indemnity.

We appreciate the opportunity to present our views on this subject which is so vital to us and are ready to cooperate with the Commission and its staff in any way possible.

Summary Statement of J. Dewey Dorsett, General Manager, Nuclear Energy Liability Insurance Association

In summary then, the liability pools feel that through administrative decision, the Commission, in its license program and contractor program, has indicated an intention to afford indemnity in areas where private insurers are able and willing to perform. In the licensee program, the proposed formula fix ng

amounts of financial protection would effectively bar private insurance from a substantial market. In the contractor program, private insurers have been almost completely excluded from the market even in areas where the indemnified operations are virtually identical to those conducted under the licensee program. We urge you to reconsider these contemplated and existing Commission policies which militate against the efforts of Congress and the administration to foster private enterprise, in which we all believe.

PIONEER SERVICE & ENGINEERING CO.,
Chicago, Ill., February 25, 1960.

Senator CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Congress of the United States,
Washington, D.C.

DEAR SENATOR ANDERSON: Once more Pioneer Service & Engineering Co. welcomes the opportunity to make a statement to be included in the record of current hearings pursuant to section 202 of the Atomic Energy Act of 1954. Our comments will be limited to atomic power and related aspects of the program.

We have recently reviewed the AEC report of February 1960 on plans for development, civilian power reactor program. It is our opinion that this represents a thoughtful and well-conceived plan. It has been our belief, and expressed view in past statements, that the best interests of the nuclear power industry will be served by an orderly program which allows the greatest practical accumulation of actual operating experience on the more promising reactor systems before commitments to a given system become inordinately great. We continue to feel that expenditure directed and tempered by the results coming out of full-scale plants represents the wisest use of funds. Proceeding in this direction we approach the normal pattern in which the power industry conducts its business.

With such a practical framework for the expanding nuclear power program it is our feeling that industry will continue to respond in appropriate manner to the evidence and direction which emerges from the Commission's experimental program on reactors and associated elements.

Even now industry is recognizing its role in research through the formation of the industrial reprocessing group composed of five electric utilities and a chemical company which plans to study the technical and economic feasibility of design, construction, and operation of a facility for reprocessing spent nuclear fuel.

Being mindful of private industry's recognition of its part in the expanding nuclear power program both as to generating plants and the associated facilities required for their continued operation, we should like to repeat some of the views we expressed a year ago. At that time we said in part as follows:

"While manufacturers of powerplant equipment and components as a regular part of their programs do a great deal of continuing research and development work, we believe that with some direct financial assistance from the Commission many would be able to do a great deal more toward the advancement of economic atomic power. In other words, some of the research and development funds provided to the Commission could be used by the equipment manufacturers to the overall advantage of the program in the area of reductions in plant investment.

"It appears to us when considering the size of prototype plants, which we assume to be first generation plants, that it is important to keep in mind that 80,000 kilowatts (electrical) is a full-scale plant for a large number of eleteric utilities. When these utilities add a plant of that size to their systems, even at an investment substantially equivalent to the current cost of a conventional plant, they must have one that is a source of dependable power reasonably free of the uncertainties of experimentation. To us, this means that prototype plants of such a size would be out of reach for too large a segment of the utility industry to accomplish the objectives of the Joint Committee and the Commission. A maximum size of 50,000 kilowatts woudl be more effective as to probable industry participation and, in our judgment, large enough to give desirable technical, operating, and cost answers. Second and third generation plants in the 80,000-kilowatt size range would be more logical."

In reflecting upon this statement we are pleased to see evidence of the Atomic Energy Commission providing more funds for research by industry.

In considering new plants we believe that we should be aware of the fact that the time is approaching when the program for plant installations, at least in part, will no longer be experimental but will become a part of the normal long-range utility plans to meet growth. For this reason it is important that new invitations for proposals take note of the time required by utilities to properly evaluate their long-range plan with respect to such invitations. We believe that the 90- to 120-day period which has been allowed on occasion is not always sufficient for the type of appraisal which will become increasingly desirable in keeping with the usual custom in the industry with respect to conventional plant additions.

Summing up, it is our conviction that order is the essence of leadership. By a firm devotion to a well-balanced program comprising experimental activity, prototype plants, and full-scale commercial powerplants conducted within an orderly framework of cooperation between the Atomic Energy Commission and industry, we believe the position of leadership for the United States in the use of atomic energy for civilian purposes can be maintained.

In our view the program which the Commission has adopted, as outlined in the February 1960 report, is a commendable one.

Respectfully submitted.

FRED C. KELLOGG, *President.*

STATEMENT SUBMITTED BY WALKER L. CISLER, PRESIDENT, POWER REACTOR DEVELOPMENT CO.

INTRODUCTION

This statement is submitted by Power Reactor Development Co. (PRDC) for inclusion in the record of the hearings being held by the Joint Committee on Atomic Energy during the 2d session of the 86th Congress pursuant to section 202 of the Atomic Energy Act.

PRDC is a nonprofit Michigan membership corporation. It is engaged under the Commission's power demonstration reactor program in the design and construction of, and will operate, the reactor portion of the Enrico Fermi Atomic Power Plant. The reactor is a developmental fast neutron power breeder reactor and the plant is located at Lagoona Beach, Monroe County, Mich. Also associated with the project are the Detroit Edison Co., which is building and will own and operate the conventional steam turbine-generator facilities which will utilize steam produced by the reactor, and Atomic Power Development Associates, Inc. (APDA), a nonprofit New York membership corporation, which is conducting important programs of research and development, including the nonnuclear test operation of full size components of the reactor.

PROJECT EXPENDITURES TO DATE

Schedule 1 attached to this statement provides a breakdown of expenditures in connection with the project through December 31, 1959, by the Detroit Edison Co., PRDC, and APDA. Detroit Edison has actually expended some $8,600,000, or 50.7 percent of the estimated total cost of the nonnuclear facilities; it has firmly contracted, however, for more than 78 percent of these facilities. PRDC and APDA together have expended some $21,800,000, or 51.6 percent of the estimated total, for equipment and construction of the nuclear portion of the plant; again more than 94 percent of the total has been firmly committed. Similarly PRDC and APDA together have expended $16,600,000 on preliminary design and research and development work. A total of some $47 million has thus been expended on the project to date by the three organizations together.

ESTIMATED PROJECT COST SUMMARY

The overall cost of research, development, and construction of the Enrico Fermi Atomic Power Plant to be borne by PRDC, APDA, and the Detroit Edison Co. totals $80,118,000, an increase of $1,188,600 over last year which is accounted for principally by increases in research and development work. The contract between the AEC and PRDC under the power demonstration reactor program provides that the Commission will perform certain fast reactor research and

development work in Commission facilities at a cost of $4,450,000, and will waive use charges for special nuclear material estimated to amount to $3,702,600. Thus the total overall costs are $88,270,600. Schedule 2 attached to this statement presents these estimates in greater detail.

Construction cost.—The estimate of total plant construction cost of the nuclear and nonnuclear facilities (schedule 2) is $59,397,000, which is $382,000 in excess of the estimate of a year ago. This increase is due primarily to an increase of approximately $500,000 in the cost of services of architect-engineers and a decrease of $118,000 in the estimated cost of certain components.

The Detroit Edison Co., which is engaged in building and will own and operate the nonnuclear conventional steam turbine-generator is filing a statement for the record of these section 202 hearings and the attention of the committee is directed to that statement for information regarding the nonnuclear component of the total estimated project cost, which is shown in schedule 2 as $17 million.

Research and development.—The estimated total research and development costs to be borne by PRDC and APDA together have been increased over the estimate submitted last year and amount to $20,721,000 of which $18,221,000 will be by APDA and $2,500,000 by PRDC (schedule 2). Of this total, $16,608,000 or some 80.2 percent had been expended by December 31, 1959 (schedule 1). The remaining $4,100,000 research and development expenditures are planned for 1960.

Financing arrangements.—Reference to schedule 2 will show that the total projected cash requirements for construciton, research, and development of PRDC total $40,820,000. These anticipated requirements are more than covered by firm commitments by PRDC's member companies to contribute to PRDC in the period 1956–61 the sum of $27,448,000, and by a $15 million loan to PRDC from a group of banks, all of which total $42,448,000. When additional 1962 contribution commitments of $3,908,000, which have been made by PRDC members, are added to this, PRDC's firm resources available to meet project construction, test, and operating expenditures to be borne by it will be $46,356,000. Repayment of the loan is guaranteed by certain PRDC member companies.

RESEARCH AND DEVELOPMENT

In the report filed with the committee last year, reference was made to experiments being conducted by Argonne National Laboratory on the experimental breeder reactor I. These experiments have demonstrated that the rigid Mark III core was completely free of the instability which marked the previous nonrigid cores and have established that there is no inherent instability in a fast reactor system. During recent months, experiments have been performed with EBR–I in which ribs have been stripped from the fuel rods to achieve a degree of nonrigidity. The data from these experiments established the presence of a positive component of the temperature coefficient which is believed to be sufficiently large to explain the instability in the previous EBR–I cores and thus to confirm that bowing of the fuel rods was the cause of that instability.

An additional important result of the EBR–I experiments is the development of further understanding of the use of a reactivity oscillator to predict the operating characteristics of a reactor by operation at low power levels. The use of the oscillator in EBR–I has indicated that while it is not possible to extrapolate stability data developed at low power over the entire power range, it is fully possible to do so over a limited range. This means that the safety of each increase in power may be reliably predicted by appropriate oscillator studies at previous power levels. The program for start-up and approach to power of the Enrico Fermi reactor has always contemplated such a step system and the wisdom, safety, and reliability of such a program appears now to be confirmed by the EBR–I experiments.

APDA has continued study of the power-temperature relationships in a reactor during power oscillations. An experimentally confirmed analytic process has been developed from this work which will prove to be a valuable tool in analyzing and predicting reactor behavior.

Despite the quite expected and encouraging results of the studies of fast reactor stability, PRDC has continued its program of so-called meltdown research. This has included experimental investigation of the effect of fission gases on fuel failure, the conduct in ZPR–III of criticality studies on configurations of fuel

resulting from melting, and simulated studies of the behavior of molten uranium in sodium. Related studies are those with respect to containment and environment. These have continued during the year and are expected to be satisfactorily concluded in the near future.

During the year, a great amount of information has been exchanged between PRDC and the United Kingdom Atomic Energy Authority (UKAEA) pursuant to an agreement entered into in the fall of 1958. A number of PRDC and APDA engineers have visited the Dounreay Experimental Reactor Establishment in Scotland for considerable periods of time to witness construction and assembly work and to be present for fuel loading and criticality of the Dounreay fast reactor. PRDC has had a number of UKAEA engineers visit its project as well. The exchange of information and visits has been of considerable value to PRDC and the cooperation shown PRDC by the UKAEA has been very gratifying.

FUEL SUBASSEMBLIES

The core of the Enrico Fermi reactor consists of a number of square stainless steel fuel subassembly cans in which the enriched uranium fuel pins are contained. The fuel pins are fabricated by coextrusion of an enriched uranium molybdenum alloy with a zirconium clad. These pins are only 0.158 inches in diameter and are 30 1/12 inches in length after the final coextrusion. Fuel pins of excellent quality are presently being fabricated by Nuclear Metals, Inc. and the D. E. Makepeace Division of Engelhard Industries under a contract with PRDC. A full core loading was originally ordered from Sylvania-Corning Nuclear Corp. as well as from Nuclear Metals and D. E. Makepeace. Sylcor has recently requested that it be relieved of its obligation to produce core subassemblies. This request was made by Sylcor after it had become clear that high quality pins were available from the other fabricator and therefore in view of Sylcor's request, PRDC has agreed to negotiate a revision in its contract with Sylcor and is discussing the increase of its order for core subassemblies with Nuclear Metals and D. E. Makepeace. Both Sylcor and Nuclear Metals, Inc., and D. E. Makepeace will continue to manufacture blanket elements.

The original fuel subassembly design contemplated that the fuel pins would be supported in the subassembly can by a structure consisting of transverse wires. Recent endurance tests of the subassembly in sodium at full flow and high temperatures have indicated that this structure creates a maldistribution of flow forces within the can which causes the pins to creep or distort in such a manner that they are no longer supported by the transverse wires. This in turn could result in a loose and nonhomogeneous array of pins within the subassembly can. Such a condition would be unacceptable, since it could possibly introduce unpredictable power coefficients of reactivity which could be positive under certain circumstances. This is not a problem inherent in this type of reactor or this type of fuel, nor is it a problem of physics at all; it is entirely mechanical.

A vigorous program is now being pursued to revise the mechanical method utilized in supporting the individual fuel pins so as to maintain a uniform fuel density within the subassembly can. Completion of this work and subsequent extensive mechanical testing will result in a delay in the availability of fuel, since, although fuel pins of more than acceptable quality are now being manufactured, they cannot be loaded into subassembly cans until the revised internal mechanical support system has been proved out and the necessary subassembly structures manufactured.

STATUS OF CONSTRUCTION AND SCHEDULE

The emphasis on construction activity changed during the year from emphasis on the completion of building structures to the placing and erection of components, extensive mechanical systems, and the installation of a large amount of electrical equipment. Erection of the reactor vessel and the reactor vessel plug were completed during the year and erection of graphite-block external shielding between the reactor vessel and the primary shield tank is now in progress. Also, during the year, the primary sodium system piping was completed, including insulation, heaters, neutron shielding, and secondary containment. Auxiliary piping systems in the reactor building were completed and these include inert gas piping, ventilation systems, and sodium service systems.

The steam generator building was completed and erection of the main steam, boiler feedwater, and secondary sodium piping systems was begun. The three

steam generator shells were delivered and have been erected and are now ready for the placement of the tube bundles which are being fabricated.

The health physics and ventilation buildings were completed during the year and the ventilation system equipment installed. Construction was also begun on the inert- and waste-gas building and has proceeded to the extent that equipment is now being fabricated in this building.

Concrete work and structural-steel erection for the fuel and repair building is now complete and equipment for cleaning irradiated fuel and blanket subassemblies is now being delivered and installed in this building. Equipment for the liquid-waste disposal system is also being fabricated and delivered to the site for installation.

For the last 2 years the project has been working toward a criticality date of September 1, 1960. The bulk of the plant construction work and component procurement is substantially on time in accordance with that goal. However, it is evident that this schedule cannot now be met because completion of definitive nonnuclear tests on the modified fuel-support design will result in delay in the availability of completed fuel subassemblies to be loaded into the reactor. In addition, it had originally been planned to carry on most of the nonnuclear component testing at the plant concurrently with the last stages of construction, and experience to date indicates that this cannot be done to the extent originally planned. Some of this testing will have to be carried out after substantial completion of the plant in the late summer of 1960.

The expected amount of delay in the startup which will result from these circumstances is not presently ascertained. It is believed, however, that they will delay the criticality of the plant 4 to 6 months after September 1, 1960.

NONNUCLEAR REACTOR COMPONENTS TEST

APDA is conducting an important in-place nonnuclear test of major reactor components and associated facilities. This test is known to the project as the reactor components test. The components and equipment being tested include the reactor vessel, surrounding primary shield tank, fuel-handling and reloading equipment and mechanisms, reactor control devices, and a primary sodium coolant loop which includes an 11,800-gallon-per-minute pump. The test consists of nonnuclear operation of such equipment, and in order to simulate as closely as possible the characteristics of the reactor, dummy fuel and blanket elements are being used in place of the uranium fuel and blanket elements which will be used during nuclear operation. Related facilities, such as sodium and inert-gas auxiliary systems, heater-cooler control equipment and instrumentation, have been installed and will be tested. This test program is designed to prove out the mechanical operating characteristics of the components and to provide experience to operating personnel prior to nuclear operation. The tests were initiated during September 1959 and initial mechanical tests of the components and associated equipment were made at normal temperatures and later at 500° F. in order to check alinement and operation of the equipment at higher temperatures. Fuel-loading equipment is now being used to load dummy fuel elements into the reactor to develop experience in the operation of such equipment. When initial tests have been completed, the system will be filled with sodium and a complete series of tests of components will be conducted with sodium at operating temperatures.

PERSONNEL TRAINING

The training program for operating personnel has been intensified during the past year. Five engineers have now completed the course of training offered at Shippingport. These men and a nuclear engineer from the company's staff are now devoting their full time at the plant site to conducting a training program, including both plant orientation and nuclear subjects, for other personnel who will be engaged in the operation of the plant.

The initial orientation program began in November 1959 and instruction in nuclear areas commenced in December. There are presently 22 persons in the training program. The seven or eight men who will take operating license examinations will supplement this onsite training by additional training on EBR–I, a sodium-cooled fast reactor, and ZPR–III, a mockup reactor, both of which are located at Arco, Idaho. This group will also be trained on the operation of the University of Michigan Phoenix project reactor.

PRDC has also purchased an operator training console which is now being fabricated and which will be used in connection with the plant simulator. It is planned that operators will obtain some of their training by operation of this training console. Both the console and the simulator will, in addition to providing a valuable training aid, be of considerable use in connection with investigation of control and operating parameters of the reactor both before and after operation is begun.

CONSTRUCTION PERMIT PROCEEDINGS

On May 26, 1959, the Atomic Energy Commission issued its opinion and final decision in the PRDC construction permit proceedings. The Commission's order, like its initial decision of December 10, 1958, continued in effect PRDC's construction permit with certain modifications which had been recommended by the Atomic Energy Commission's Separated Staff and to which PRDC did not object. The order provides for continued review by the Commission of the safety characteristics of the proposed reactor and for further proceedings prior to issuance of an operating license. It also provides that PRDC is to file quarterly technical reports and semiannual financial reports. Four such quarterly technical reports and two semiannual financial reports have been filed with the Atomic Energy Commission.

The intervening unions petitioned the U.S. Court of Appeals for the District of Columbia Circuit to review the opinion and order of the AEC, and PRDC and the State of Michigan were granted permission to intervene in these proceedings in the court of appeals. Briefs have now been filed by all parties and it is anticipated that the case will be argued before the court of appeals in March 1960.

CONCLUSION

PRDC is now preparing sections of its Hazards Summary Report and taking the other steps preparatory to submission of material for evaluation by the Advisory Committee on Reactor Safeguards and the Commission in connection with application for an operating license.

SCHEDULE I.—*Enrico Fermi plant expenditures to date by the Detroit Edison Co., Power Reactor Development Co., and Atomic Power Development Associates, Inc.*

	Expenditures through Dec. 31, 1959	Estimated total cost	Percent expended
Nonnuclear portion of plant: Plant expenditures by the Detroit Edison Co.	$8,620,318	$17,000,000	50.7
Nuclear portion of plant:			
Expenditures by PRDC:			
Direct plant expenditures [1]	12,229,550	----------	----------
Fuel element fabrication expenditures [2]	1,599,800	----------	----------
Other construction and test expenditures [3]	4,364,442	----------	----------
Direct plant expenditures by APDA [4]	3,681,000	----------	----------
Total	21,874,792	42,397,000	51.6
Research and development:			
Expenditures by PRDC	1,166,135	----------	----------
Expenditures by APDA of benefit to Fermi plant [5]	15,442,000	----------	----------
Total	16,608,135	20,721,000	80.2
Grand total	47,103,245	80,118,000	58.8

[1] Not including expenditures on fabrication of fuel and blanket elements.
[2] This covers initial expenditures on contracts for the fabrication of 1 complete blanket and 2 complete core loadings.
[3] This includes all indirect plant construction costs with the exception of research and development expenses, which are separately listed. Included herein are expenditures for interest, taxes, insurance, and administrative and overhead.
[4] This covers expenditures by APDA allocable to the purchase and installation of equipment which will be transferred to PRDC after nonnuclear testing and which will be incorporated into the nuclear portion of the plant.
[5] This includes those research and development and administrative expenses of APDA from 1952 through 1959 which have been of benefit to the Fermi project.

SCHEDULE 2.—*Estimated overall cost summary—Enrico Fermi plant*

	PRDC	APDA	Detroit Edison	Total
Nonnuclear portion of plant:				
Site and development			$1,210,000	$1,210,000
Structures and equipment			15,590,000	15,590,000
Interest during construction			200,000	200,000
Total			17,000,000	17,000,000
Nuclear portion of plant:				
Direct and indirect plant cost [1]	$33,850,000	[2] $4,077,000		37,927,000
Fuel element fabrication [3]	4,470,000			4,470,000
Total	38,320,000	[2] 4,077,000		42,397,000
Total nuclear and nonnuclear plant costs	38,320,000	4,077,000	17,000,000	59,397,000
Research and development by APDA-PRDC:				
Actual (1952–59)	1,166,135	15,442,000		16,608,135
Estimated (1960–61)	1,333,865	[4] 2,779,000		4,112,865
Total	2,500,000	18,221,000		20,721,000
Grand total	40,820,000	22,298,000	17,000,000	80,118,000
Research and development work by AEC in Commission facilities				4,450,000
Use charges to be waived by AEC to Aug. 31, 1965				[5] 3,702,600
Total				8,152,600
Total overall costs				88,270,600

[1] This includes all direct and indirect plant construction and nuclear testing costs with the exception of fuel element fabrication and research and development, listed separately herein. Included herein are interest, taxes, insurance, employee training, administrative and overhead expenses, and all costs of operation during a test period of a full year.

[2] APDA is purchasing and installing certain equipment and devices which, after nonnuclear testing by APDA, will be transferred to PRDC and incorporated into the reactor plant. These components are estimated to cost APDA $4,077,000.

[3] This includes fabrication costs for not only the initial core and blanket loading, but for a second complete core loading as well.

[4] This includes APDA research and development work and administrative expenses, including material and supplies required for the nonnuclear testing but not incorporated into the permanent reactor plant, for the year 1960 only. Since substantial work of benefit to the project will also be done by APDA subsequent to 1960, this represents a minimum estimated figure.

[5] By the terms of the AEC-PRDC contract effective Jan. 1, 1957, use charges for special nuclear material are waived for the period ending 5 years after the date of PRDC's facility license. On the basis of its present schedule, this date would be Aug. 31, 1960, so that the waiver period would terminate Aug. 31, 1965.

STATEMENT BY V. L. PARSEGIAN, DEAN, SCHOOL OF ENGINEERING, AND PROFESSOR OF NUCLEAR ENGINEERING, RENSSELAER POLYTECHNIC INSTITUTE, TROY, N.Y., TOGETHER WITH A LETTER FROM DR. PARSEGIAN, DATED NOVEMBER 16, 1960

RENSSELAER POLYTECHNIC INSTITUTE,
Troy, N.Y., February 15, 1960.

Senator CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Congress of the United States,
U.S. Capitol, Washington, D.C.

DEAR SENATOR ANDERSON: I have read with considerable interest your recent talk on "The Peaceful Atom: Fact or Fable," which reviewed the tortuous path of atomic energy. I should like, in this letter, to dwell not on the disappointments of the past but on some steps that may help to secure the future in certain technical areas.

More specifically, I should like to speak to radioactive isotopes, which you so aptly called "breadwinners" of atomic energy and "rays of light," and discuss their importance to the education of our youth.

The scientists and engineers who will ultimately achieve success with fission energy and fusion energy are not likely to come from the ranks of those who are weary from these early struggles, but from among those who are now studying in colleges and high schools. This is why it is so critically important that new scientists and engineers be prepared to make full use of new techniques and ideas of the nuclear age when they go out into the world.

The enthusiasm you expressed with the isotope picture is certainly justified. It is wonderful that atomic techniques offer hope that we shall at long last learn more about basic processes of life and death, of plant growth, and of behavior of processes of many types. Radioactive tracers and nuclear radiation have added amazing sensitivity, new variables, and wholly new research approaches with which to attack the secrets of nature.

On another side, too few of us realize that the vast chemical and materials industries that have grown over past decades were built not on clear understanding of how atoms behave, but instead largely on technical experience and on clever trial-and-error processes. This is why it is so difficult to systematically reach for new chemicals, new drugs, new propellants, and new materials to satisfy our needs. The very base of technology is weak, because we have been forced to depend more on art than on science.

This being the challenge, we can ill afford to permit educational institutions to continue in the thinking and limitations of earlier decades. The educational process is expensive, but it can become tragically more expensive if it stops short of achieving appreciation of its own decade.

I. The problem has two aspects as I see it. The first has to do with the education of the many college graduates who are not nuclear specialists but who must be assured a broad base of educated thinking which is responsive and responsible to the needs of this decade. It is unthinkable that our citizens can cope with problems of radiation hazards, extensive nuclear power, community welfare, and the role of atomic operations if the education offered by physics courses at college goes little beyond sliding blocks and Archimedes' principle. Physics and other science courses should include experiments with nuclear radiation and radioactive isotopes.

The second aspect has to do with preparation of specialists who will make the most of new techniques for advancement of knowledge. As an example, at Rensselaer Polytechnic Institute, teams of faculty members and graduate students have been studying interactions of the atoms nitrogen, oxygen, carbon, and hydrogen, which are so important to life and to industry. The work is sponsored by several agencies, including the AEC. On the one hand the work gives some understanding of chemical activity in the upper atmosphere, where one may even ask whether such chemical reactions can be made useful for space travel. Even more important, they seek ways for producing commercial nitrogen products and organic products by use of nuclear radiation and especially by use of fission recoil energies inside nuclear reactors.

The technical hurdles are severe, but the opportunities they open are exciting and far reaching should these objectives be achieved. Even if the projects should fall short of objectives, the gain will be enormous because the studies help to explain phenomena which relate to both nuclear and nonnuclear industries.

The point to all this is to urge Congress to strengthen our educational system by helping colleges to become familiar with the techniques and progress of nuclear energy, having in mind both the nonspecialists and specialists.

II. How can we help the smaller colleges to do this? Commissioner John F. Floberg of the AEC has pointed out that of $14 million expended in equipment grants, less than 2 percent went to small colleges and universities that turn out one-fifth of college graduates. The reason is that these small colleges do not have sufficient familiarity with atomic matters to be able to apply for equipment aid, or to justify their requests in terms of active people and active interest. They cannot compete with colleges that know what they want, and there is not enough money allotted to take care of all requests.

Perhaps the only way to help these colleges is to authorize sufficient funds for equipment, and liberal policies to permit the AEC to grant $10,000 to $20,000 to each institution that teaches science courses. With this help each can introduce very good experiments in measurement of radiation and properties of isotopes.

On the other side, how can we help the more advanced schools to prepare experts at doctoral level? The formula for turning out good research scientists and engineers is to expose them to good teaching and to give them personal experience in research techniques under good tutelage. But this means more funds for research.

My plea is to authorize adequate funds to the several divisions of the AEC wherewith to support research in radiation chemistry, tracer research, and materials research. I have been familiar with the work of the Division of Reactor Development, Division of Research, and Office of Isotopes Development. The

support of this category of research by these divisions has been properly restrained and conservative, and in general well administered, in my opinion.

III. The question may be asked, "To what extent can industry support research of this character with its own funds"? Certainly industry has achieved some success in applications such as thickness control by use of nuclear radiation, and it can be expected to support all development work that relates to commercial products. But unfortunately this represents only a small fraction of the research job that is needed at this time. It is unlikely that industry can allot very many dollars to this basic research, because the possible gains to its interests are not sufficiently clearcut or direct to warrant large expenditures. For example, it would be unrealistic to expect large industrial funding to support research in basic mechanisms of chemistry, or the development of reactors for chemical processing, or even much of the handbook data and chemical processing data that must precede large growth of this science and technology.

Respectfully submitted.

V. L. PARSEGIAN,
Dean, School of Engineering.

RENSSELAER POLYTECHNIC INSTITUTE,
Troy, N.Y., November 16, 1959.

The Honorable CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Congress of the United States, U.S. Capitol, Washington, D.C.

DEAR SENATOR ANDERSON: It has been several years since I first appeared before the Joint Committee to discuss the harm done to the Nation's colleges by atomic secrecy. Fortunately, this situation is being largely corrected.

But while secrecy walls are lowered, other obstacles continue to prevent colleges from giving full support to the nuclear program.

There continues to be indifference toward nuclear work in many quarters, from the long years of separation from classified activities. This will be a decreasing problem as faculties are enabled to get into atomic work.

The more serious obstacle results from financial inability on the part of colleges to provide opportunity for faculty to learn about nuclear developments, and equipment with which to undertake nuclear teaching. Only a small fraction of science and engineering colleges are adequately prepared, staffwise and equipmentwise, to teach radiation chemistry, radiation physics, and the like. This means that students cannot be adequately prepared for the nuclear age.

This letter is a plea to the Joint Committee to increase support to the educational program of the Atomic Energy Commission, to a level that will strengthen science and engineering colleges for teaching nuclear science.

We have been very fortunate at Rensselaer Polytechnic Institute. A substantial grant has strengthened many of our academic departments and laboratories to include nuclear subjects. Ten departments offer a major program of 20 graduate courses pertaining to nuclear science and engineering; total enrollment for these courses exceeded 1,000 during the past 2 years, by students from many disciplines working toward master's and doctoral degrees. Under a cooperative program, Rensselaer provides graduate nuclear instruction at the Knolls Atomic Power Laboratory.

It is unlikely that the quality of instruction we seek could be achieved without this equipment aid from the AEC. Also, nine of our faculty members have attended the ASEE–AEC Summer Nuclear Institutes.

Most engineering schools in this country are still trying to achieve a first start in this direction. They need help. Also two engineering colleges in India and one in Mexico are seeking help through us to establish similar programs. Aid toward achieving their nuclear goals would strengthen friendly ties with these nations.

This is not to imply that colleges should go heavily into nuclear engineering, or that every college should have a critical reactor. Indeed at Rensselaer we have chosen instead a subcritical reactor with pulsed neutron source to be much more educational than a low power critical reactor. Also we have carefully avoided establishing a separate nuclear engineering department but instead have brought many departments to support the nuclear program. We believe this broader participation to be the preferred approach for solving the advanced problems of reactor physics, radiochemistry, materials and metallurgy, stress strain in heat transfer systems, biology, management, chemical engineering, et cetera.

I have followed the grant program of the AEC with considerable interest, and have respect for the way the program has been administered. Great care has

been exercised in disbursing these funds. The job has been difficult because many of the colleges are still in process of shaping their plans.

I urge that Congress substantially increase the level of grants to colleges for equipment aid, for source and special nuclear materials, and the program for summer institutes and fellowships in nuclear science and engineering. It is likely that this higher level should be planned for a period of 5 years, after which the colleges should be in much stronger position.

We cannot overstress the importance of this program. Clearly, competition with Russia must be won not by greatly increasing the number of engineers and scientists, but by greatly improving the quality of their preparation. This requires the best possible education for undergraduates, and also that many more of them continue into graduate study. Education is expensive, but it becomes tragically wasteful as well if colleges are denied adequate equipment aids for teaching atomic science.

It is of interest to note that faculty members visiting European colleges have been greatly impressed with the quality and quantity of laboratory facilities that they observed.

If more information should be needed I am willing to appear before your Committee at your pleasure.

With personal regards, I am,

Respectfully yours,

V. L. PARSEGIAN,

Dean, School of Engineering, and Professor of Nuclear Engineering.

RURAL COOPERATIVE POWER ASSOCIATION,
Elk River, Minn., February 10, 1960.

MR. CLINTON P. ANDERSON,
Chairman, Congress of the United States, Joint Committee on Atomic Energy, Washington, D.C.

DEAR MR. ANDERSON: Thank you for your kind invitation of January 20, 1960, to appear before your committee for our comment on atomic affairs.

I find myself unable to appear, or to submit to you very substantial comments on the field at this time. We have been working long hours in taking care of our responsibilities, which will culminate with the successful operation of a boiling water reactor, which we hope will be energized in December of this year. I am sure you can appreciate the vast amount of activity this involves.

I am advised by our planning department that our thoughts and anxieties as to future nuclear generating capacity appears to be more concerned with finding a more suitable and lower cost method of achieving containment for isolation of the radiation forces inherent in a reactor. Apparently our people, and the contractor, Allis-Chalmers, are quite pleased at results in lowering energy costs. Our cost of fabrication, when bids weer received, was approximately 50 percent of the cost estimated at the time of contract negotiations, and so it appears to us that while research and development should be sincerely continued in the field affecting fuel, that more daring steps of engineering and construction should concentrate in reducing the installed costs per kilovolt-ampere.

We believe there are some interests in how to more cheaply isolate the reactor and its inherent radiation and thus permit a more conventional treatment of the balance of the conventional steam components. We are extremely interested in the developments of superheat in the reactor and feel that this too will make a substantial contribution toward fully utilizing the efficient turbine equipment available today.

I know these are general comments but I thought they would be valuable as coming from a group who is atomic minded. I have complimented you and your committee in the past for your strong leadership and effectiveness in moving these programs ahead on an international basis. That you are again, today, seeking more problems and their solutions is certainly a further expression of your dedication to place America out in front of the world in technological achievement. I trust you are soon successful in making the United States a mecca for technicians throughout the world, and further, that these powers of mass destruction are only exceeded by our technical ability to serve mankind better.

Sincerely yours,

O. N. GRAVGAARD, *President.*

SMALLER BUSINESS OF AMERICA, INC.,
Cleveland, Ohio, February 12, 1960.

To Members of the Joint Committee on Atomic Energy, U.S. Senate and House of Representatives, Washington, D.C.:

Permit us to present a resolution on atomic energy for your kind consideration.

This resolution has been drawn up by our Patent and Trademark Committee: Jack M. Young, chairman; Thomas E. Fisher, Richard MacCutcheon, and John W. Robb (all patent and trademark attorneys), and passed by our board of trustees.

Respectfully submitted.

S. R. CHRISTOPHERSEN,
Executive Vice President.

RESOLUTION ON ATOMIC ENERGY ACT

Smaller Business of America, Inc., favors the changes set out in the proposed bill submitted by the Atomic Energy Commission to modify the Atomic Energy Act for the reasons listed below and also recommends additional revisions indicated below:

1. The recommended changes all liberalize the act in favor of the American citizen and smaller business thus tending to foster and improve the utilization of atomic energy.

2. The act, as amended, is still too stringent and constrictive tending to limit the participating companies to big corporations to discriminate against smaller business.

3. It is submitted that a small corporation must be able to obtain proprietary items in order to compete with larger and better known corporations in anything but very specialized fields which are not of interest to the large corporation. For this reason small business participation in the atomic energy industry has been confined to such specialized devices as specialized instruments for measuring radioactivity.

4. It is submitted that the committee should consider the following factors which are believed to be defects in the present act:

(*a*) No inventor can be sure he has a valid patent because secret material to which he has no access may bar his patent.

(*b*) It is impossible for any invention to be made in the atomic energy field without giving rise to a plausible argument, "that it is made, in the course of or under, arrangement," with the Atomic Energy Commission. The Commission has taken the position that an actual reduction to practice is necessary before an invention is made. One cannot actually reduce an invention to practice which utilizes atomic energy without some arrangement with the Commission since one must be licensed by the Commission to obtain source material from the Commission. Thus, a cloud is put on the title of every patent pertaining to atomic energy unless the Commission has explicitly waived any ownership claim. Smaller business cannot afford to enter into industry under such conditions.

(*c*) It is believed improper for the AEC to claim title to an invention when the invention has been conceived and constructively reduced to practice in a patent application by an inventor on his own time and his own expense. The AEC so claims title to said invention where there is some nominal affiliation with the AEC at the time when the first working model is actually made.

(*d*) Section 153 should be modified to limit the scope to the purpose for which the Commission says it needs the section. It should not be so broad as to threaten the right of others. If the Commission needs this section to guard against the possibility of a patent issuing which covers some facet of an expensive installation which had been made prior to the issuance of the patent, the section should be modified to guard against the possibility of that eventuality and no more.

(*e*) Section 155 should be modified, at least, to be limited to that prior art which was kept secret because of a validity instituted secrecy regulation of the U.S. Government. Under the scope of the present provision one can argue that concepts privately made which do not rise to the level of classifiable material would nonetheless be a bar to inventions independently made by others if these concepts were secret because the person who had them worked for the AEC but did not disclose them to others.

SOUTHWEST ATOMIC ENERGY ASSOCIATES,
Little Rock, Ark., February 12, 1960.

Subject: Statement for the record, section 202 hearings.

Senator CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR SENATOR ANDERSON: During the past year, the research and development activities of the Southwest Atomic Energy Associates on an advanced epithermal thorium reactor concept (AETR) have moved into high gear.

As you recall, the Southwest Atomic Energy Associates is a group of 15 electric utility companies located in the southwestern region of the United States. These companies have joined forces to sponsor development aimed at producing nuclear electricity at a cost competitive with conventional fuels in this region where fossil fuels are relatively low in cost.

In January 1958, the Associates entered a contract with Atomics International Division of North American Aviation, Inc., to carry out a $5,340,000 research program of about 4 years duration aimed at investigating the technical and economic promise of an advanced concept, which we considered to have good prospects for producing electricity as cheaply as that we can expect to produce with a gas a few years hence.

The first phase of the project was completed in June of 1959. This included a thorough analysis of existing physics data on U^{233}, thorium and other materials involved in the operation of a reactor in the epithermal (intermediate and fast) neutron energy range, as well as limited experimental work to determine new physics data. Considerable effort was also spent on perfecting computer codes and techniques and on developing a reference design for subsequent study, as well as overall evaluation of the concept. The phase I investigations uncovered no information which would make the concept appear to be less promising than when the project was initiated. If anything, both Atomics International and Southwest Atomic Energy Associates are even more optimistic now, although it was recognized from the outset that the ultimate promise of the concept is very strongly dependent on experimental physics data which will be derived from critical experiments. The work of the next 2 to 3 years will be devoted largely to conducting critical experiments and analysis of the concept based on the results of these experiments and other work on physics, fuel element development, and core analysis.

In my letter to your committee last year, I indicated that progress on the AETR project had been slowed down pending a response from the Atomic Energy Commission regarding our request for U^{233} needed for the critical experiments.

In April 1959, the Atomic Energy Commission agreed to make 25 kilograms of U^{233} available for the epithermal critical experiments. Design of the critical experiment facility was promptly completed, and application was made for a construction permit. The latter was granted by the Atomic Energy Commission in December 1959. Construction is in full swing, and the first critical experiment is expected to be underway about July 1960.

Because of the limited quantity of U^{233} available, a rather unique arrangement and design has been devised for the critical assembly. The U^{233} will be inserted in the center of an epithermal region, with U^{235} as the principal fuel. The epithermal region will be surrounded in turn by a buffer lattice whose principal function is to maintain the desired neutron energy spectrum in the test region independent of the spectrum in a thermal neutron drive region which surrounds the entire assembly.

Such an arrangement requires a relatively small amount of fissionable material compared to a uniformly loaded assembly of the proper characteristics (a full scale reactor will require 400 kilograms or more of U^{233}). Nevertheless, with careful attention to design and particularly to instrumentation and analytical interpretation, we expect the results to be adequate for evaluating the prospect for the concept and possibly for detailed design of a full scale reactor core.

I hope by next year I can report some of the results obtained by using the critical facility.

Yours sincerely,

J. ROBERT WELSH, *President.*

SYLVANIA-CORNING NUCLEAR CORP.,
Bayside, N.Y., February 5, 1960.

Hon. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Washington, D.C.

DEAR SENATOR ANDERSON: I want to thank you for the kind invitation extended in your letter of January 20 for me to testify or submit a statement for the record in connection with this year's hearings on the development, growth and state of the atomic energy industry.

In reviewing the suggested topics attached to your January 20 letter, I feel that I and other representatives of Sylcor have testified in great detail in the past on the subjects which we feel are of primary interest to Sylcor and the industry, including the civilian power program, AEC contract policies and patent problems. As I have indicated to you in the past, we have been extremely gratified by the interest and response of members of the Joint Committee to the problems with which we have been concerned. Most recently I have had occasion to express our appreciation in connection with the amendment of section 161M of the Atomic Energy Act to permit companies such as Sylcor to enter into agreements for reprocessing of fuel elements directly with the AEC. You will be interested to know that Sylcor has already taken positive steps in an effort to enter the areas which this amendment has opened up to us.

In view of our detailed testimony and statements in past year, I do not feel warranted in further taking the committee's time in reiterating Sylcor's views at the present hearings. I would only make the additional suggestion at this time that there is a need for close attention to the incipient problem presented by possible competition of the National Laboratories with private nuclear industry. This is a subject which, as you undoubtedly know, has already received the attention of the Bureau of the Budget in connection with its Bulletin 60–2 and which I am sure is presently being reviewed in detail by the AEC itself. I think that the conclusions which are arrived at by the Commission in this area will have a vital impact on the degree to which private industry can move forward in the field.

Very truly yours,

LEE L. DAVENPORT.

TEXAS INSTRUMENTS, INC.,
Dallas, Tex., February 11, 1960.

The Honorable CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Congress of the United States,
Washington, D.C.

MY DEAR SENATOR: We have received your letter of January 20 soliciting our views on the development, growth, and state of the atomic energy industry. Texas Instruments is a diversified company whose operations include the development and production of semiconductor devices, development and production of complex electronic and electromechanical systems for Government use, conduct of geophysical services, the fabrication of clad metal products, the manufacture of thermostatic and electrical controls, and the production of nuclear fuel elements and cores for the Government and other customers. Through these activities we have a broad interest in advanced energy generation and conversion technology. Our activities in the nuclear field are carried on through a wholly owned subsidiary, M. & C. Nuclear, Inc.

In recent years the atomic energy industry has developed to a point where the probability of economic nuclear power has become very real. In analyzing the comparative costs of generating power via nuclear energy versus fossil fuels, it becomes apparent that the economic balance of the two methods lies largely in the difference of fuel cost. Thus, the attainment of economically competitive nuclear energy will depend largely on an ability to produce a satisfactory fuel cycle for nuclear reactors at a cost lower than the existing and expected costs of fossil fuels.

At present there is an overcapacity in the nuclear fuel manufacturing industry. It has been conservatively estimated that all of the fuel required in the next 5- to 10-year period for industrial nuclear power generating facilities could be manufactured by the capacity of existing plants involved in the naval propulsion program and that there would still be resulting excess capacity. Obviously, it is to the national interest for plants qualified to manufacture naval propulsion fuel to maintain an adequate state of activity.

The consequence of overcapacity in part is to deter the conduct of a sufficiently aggressive research and development program directed toward methods of reducing the cost of fuel fabrication. Further, it seems imperative that a considerable amount of this research and development must be conducted by those industrial organizations who have, and will continue to have, the manufacturing responsibility, since they are best able to resolve the inevitable compromises between fuel performance and cost and ease of manufacturing. It should be pointed out that in this instance we are speaking of the complete fuel cycle, and included in such analysis and deliberations must be the cost of refining and enriching the fissionable materials used. Failure to carry on a sufficient research and development effort within industry toward lowering fuel costs strikes at the very balance point involved in achieving competitive nuclear power.

In this regard it seems highly desirable that continued and expanded responsibility for reducing the cost of nuclear fuel must be given to the private fuel fabricator, with the result that necessary programs are outlined and conducted by this industry. It is hoped that the current efforts of several of the national laboratories, including Bettis, KAPL, and Argonne of the AEC, to analyze their fuel development work and wherever possible to place it with private industry, will also continue and expand. This effort increases the knowledge of industry and improves its opportunity to contribute to more economic nuclear fuel. Such efforts should be encouraged and accelerated to the end that the time required to achieve economically competitive nuclear power is minimized.

We also think it is appropriate to refer to the fact that under existing commission policy there has not as yet been any contract indemnity coverage under section 170d of the Atomic Energy Act granted to fuel fabricators as such coverage is granted to reactor operators. We are aware that a technical study is being made of this subject, and we hope that this study can be brought to a rapid conclusion because many of the fuel fabricators, such as we, are engaged in fabrication programs which involve assembling complete cores with the attendant high power ratings concerned in the naval propulsion program.

We thank you for the opportunity to comment on these important matters.

Yours very truly,

P. E. HAGGERTY, *President.*

UTAH MINING ASSOCIATION,
Salt Lake City, Utah, February 23, 1960.

Re section 202 hearings, February 16 through 25, 1960.

Hon. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy, Senate Office Building, Washington, D.C.

DEAR SENATOR ANDERSON: I regret that my very recent return to Utah has made it impossible to prepare a statement for personal presentation at the current section 202 hearings.

The statement of our association presented at the 1959 hearings expressed concern about—

1. The AEC exercising options for extension of Canadian contracts.
2. Facilitating the extension of domestic milling contracts to 1966.

An AEC announcement of November 6, 1959, advised of the decision to stretch out present Canadian contracts, rather than to maintain the contracts status quo as to time termination, or to exercise options for additional purchases beyond quantity purchases stipulated. This seems to dispose of the threat of the options being exercised for additional tonnages.

There has been some progress on mill contract extensions, for the Commission's information release No. 260, January 30, 1960, shows nine mills having contracts to 1966, compared with four with such contracts at approximately this same date a year ago. This represents real progress and we look forward with interest to final arrangements for extension of all mill contracts where ore reserve potential permits such extended operation. It is our understanding that there are ore reserves not covered by contracts for milling and we urge that the Commission give consideration to provisions for the mining of such reserves while considering mill contract extensions.

We visualize a problem in mills adjusting to either anticipated or unexpected ore reserve exhaustion and urge that every effort be made to allocate sufficient

eligible ore to mills to insure, to the extent possible, that mills are not forced to operate at uneconomic levels—a situation which would not only be detrimental to the affected mill but which could penalize the supplying miners in terms of service and of price for his ore. We also urge that the Commission consider permitting mine operators the exercise of some judgment as to the source of ore in their filling mine tonnage allocations, in cases where such operators have more than one mine in the area served by a mill to which each of the operators' mines are tributary.

In view of the need for mines and mills to adjust to an industrial market, a transition necessarily related to the 1966 purchase program termination date, we would suggest that thought be given to permitting further processing of uranium in connection with milling. Production of more advanced or premium grade products would strengthen the position of both the mill operator and the miner in transition to industrial market conditions.

Thanking you for your sustained and helpful interest in the industry's problems, I am

Yours very truly,

MILES P. ROMNEY, *Manager.*

STATEMENT FOR THE RECORD BY MR. PHILIP N. ROSS, GENERAL MANAGER, WESTINGHOUSE ELECTRIC CORPORATION, BETTIS ATOMIC POWER LABORATORY, PITTSBURGH, PA.

The Bettis Atomic Power Laboratory, which is operated for the U.S. Atomic Energy Commission by the Westinghouse Electric Corp., has from its inception in 1949 devoted its efforts to the development of basic nuclear atomic reactor technology through research and the design of nuclear powerplants for Navy ships and for the Shippingport central station.

After completing the pioneering work for the first nuclear-powered submarine, U.S.S. *Nautilus*, Bettis has proceeded with the development of the nuclear propulsion systems for the *Skate* class fleet-type submarines, the *Skipjack* class high-speed attack submarines, the prototype reactor plant for the guided-missile cruiser *Long Beach* and the aircraft carrier *Enterprise*, and the reactor powerplant for the Nation's first atomic power central station at Shippingport.

The large nuclear industrial base existing today and the number of nuclear plants under construction using Bettis developments is indicative of the magnitude of the laboratory's technological contribution.

Participation by all segments of American industry, from large steel companies to small instrument makers, has always been sought and actively encouraged for the furnishing of components in all Bettis reactor plant developments. For example, all of the reactor plant components, including the nuclear-reactor cores, for the *Skate*, *Skipjack*, and *George Washington* class submarines and the guided missile cruiser *Long Beach* and aircraft carrier *Enterprise* have or are being furnished by qualified commercial vendors on fixed price contracts. In the case of the PWR at Shippingport, components from over 2,000 vendors from across the Nation were used. Many of these firms acquired new skills. This large participation by industry is in accord with the basic Commission policy of contracting the responsibility for design and manufacture of any component to commercial vendors as soon as the basic development work is completed. Adherence to this policy has resulted in the establishment of a sizable private atomic energy industry.

Bettis perfected ideas and technology have become the basis for many nuclear powerplants now being built. This is illustrated in the fact that the basic data which Bettis developed on uranium oxide fuel has been adopted for most of the civilian power reactors planned or under construction: namely, Dresden, Indian Point, Yankee, Selni, and Humboldt Bay. The knowledge of heat transfer and hydraulics of water reactors is essentiallly the result of Bettis work. Digital computer codes such as Monte Carlo, Wanda, and Turbo, and other reactor physics analysis methods developed by Bettis are in widespread use throughout the nuclear field. In addition, many of the primary plant components developed through the Bettis work, such as large reactor vessels, vertical U-tube heat exchangers, high capacity canned motor primary coolant pumps, and improved hermetically sealed control drive mechanisms are becoming standard reactor items.

The technology that has been developed for both the naval program and the Shippingport project is available to all of our industry. For example, well over

2,000 documents and manuals on the Shippingport project have been published and distributed.

It is appropriate to note at this point that each succeeding step in the advance of a technology demands far greater sophistication and precision in the treatment of the problems involved than was required in the preceding levels of development. This, in turn, means that increasing emphasis must be placed on acquiring basic insight and understanding. As a result, each incremental advance is more costly in manpower and dollars. The high cost of developing and proving out a new fuel material or element demonstrates the point. The high cost of digital machine design computations is a further illustration.

Nuclear technology, at present, is being advanced at Bettis through the efforts to reduce both the capital costs and fuel costs of pressurized water reactors. This cost reduction will be applicable to both naval and civilian power reactors. Advances in core technology—in terms of lifetime capability, power capability, and fuel element fabrication techniques—will have the most telling effect on reducing costs. These advances will affect directly not only the fuel costs, but also the plant capital costs. The latter cost reduction derives from the fact that cores with high specific power capability will impose a lower burden on the plant per unit of heat removed from the core. The reductions in fuel costs derivable from increases in core lifetime or energy output, especially when combined with lower core manufacturing costs, are obvious. Thus, there are real gains to be made in concentrating on core development in attempting to achieve reduced costs of nuclear power.

As further emphasis, I would like to cite in more detail some results of the research and development gains derived from the Shippingport central station project. The refueling of the reactor's first seed (PWR core 1, seed 1) is nearing completion. This is the first time a large central station nuclear power reactor has been refueled in this country. A new 32-cluster seed has been inserted, and the plant will resume its role as the Nation's first large-scale producer of electrical power from nuclear fuel in the near future. The success of Shippingport as a major contributor to the Nation's nuclear technology is evidenced by the performance of the first seed which lasted the equivalent of 5,800 full-power-hours—2,800 hours above the design of 3,000 equivalent full-power-hours. On this first seed Shippingport produced approximately 400 million kilowatt-hours of electrical power from December 1957 to November 1959, when refueling operations were started.

The new seed (seed 2) which is now in core 1 is designed with a lifetime of approximately 7,500 full-power-hours—two and one-half times the design life of the first seed.

During the refueling a number of fuel elements were also extracted from the core's blanket. This will permit the first extensive study of natural uranium fuel which has undergone long irradiation, at high temperatures, and pressures in a large power-producing reactor. Also, the refueling has resulted in obtaining firsthand experience with the unit refueling of large reactor cores. The procedures developed for these refueling operations have proved successful.

Greater insight into our progress in achieving advances in core technology can be seen from the advances being made in going from the PWR core 1 design to the PWR core 2 design. We have at present in the initial stages of manufacture the PWR core 2, with a design rating of 150 milliwatts gross electrical. This core has five times the design energy output and twice the power density of PWR core 1. And yet PWR core 2 will be suitable for installation in the present Shipping port reactor vessel.

In the field of naval reactor improvements, advanced reactivity lifetime cores are under development which are expected to significantly reduce fuel costs and increase the interval between core refuelings. The development associated with improved naval cores is not a simple extrapolation of previous designs but entails major improvements in performance and step advances in basic technology. They will thus require a major effort in terms of both manpower and dollars and should be viewed as the second generation of water reactor cores.

No major new Bettis facilities are planned in the foreseeable future. However, a number of facilities important to the laboratory's development work are nearing final stages of completion. Installation of a Transac computer is expected to be completed by February 1960. This high-speed electronic digital computer will replace the IBM–704 and make it possible to apply advanced analytical methods in the calculation on a three-dimensional basis of the nuclear and thermal characteristics of long-life, high-performance cores. An ex-

pansion of the hot laboratory will provide the added capacity for making post-irradiation measurements needed for the extensive experiments associated with development of fuel elements capable of withstanding long irradiation exposure.

Recently, a new critical high temperature test facility began experimentation on reactor cores in an environment similar to that encountered in an operational, power producing reactor. This facility will greatly aid in the effort to advance our knowledge of the internal workings of large pressurized water reactors, it is a safe, flexible, and fully instrumented zero power facility on which we can directly improve our core design concepts.

The future program planned for the Bettis plant is thus a concentrated development effort in those areas of water reactor technology most essential to achieving reduced plant capital costs and fuel costs for naval nuclear propulsion plants as well as for nuclear power central stations. The program is built upon, and will take maximum advantage of the accomplishments to date and is expected to result in significant advances in the basic technology of water reactors. For this reason Bettis will, as in the past, contribute significantly to the entire power reactor field. These advances in basic technology will provide a basis for further exploitation by industry just as has occurred in the case of the *Nautilus* and the first generation Navy and Shippingport developments.

WYOMING MINING ASSOCIATION,
Riverton, Wyo., January 27, 1960.

Hon. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
U. S. Capitol Building, Washington, D.C.

DEAR SENATOR ANDERSON: We appreciate the opportunity, which the Joint Committee has afforded us, to present this brief statement, relative to our views on the present state of the atomic energy industry.

Our interests, primarily, are in the mining and the concentrating of uranium ores. We do not feel that we can comment on the many other phases of the atomic energy program. We do recognize, however, that the development of peaceful uses of nuclear energy, is important to the continued growth and welfare of the uranium mining industry. The interest of your committee on this subject, gives us confidence that there will be continued progress by Government and private industry in the field of research and development.

We are concerned by the decreased amount of exploration for uranium ores at the present time. The increasing cost of exploration for uranium, the lack of a market for additional ores today, and the uncertainty regarding markets after 1966, add to this problem. We believe that your committee is aware of this situation and we urge that continued efforts be made to encourage the development of adequate marketing facilities for private industry.

With the completion of two additional uranium mills during the past 2 months, the Wyoming uranium industry should make a substantial contribution to the supplies of U_3O_8 during 1960 and succeeding years. Our mill contracts now call for the concentrating of approximately 3,300 tons of ore daily. This will permit a reasonable production schedule in most of our mines.

The Shirley Basin area in central Wyoming, gives promise of very substantial reserves of better than average grade ore. We believe that the owners of these properties, who have spent large sums in proving these ore bodies, should be given an opportunity to develop their mines and a market should be provided for reasonable and economic production from such mines. This may justify the construction of a concentrating mill in the Shirley Basin.

We commend your committee and the Atomic Energy Commission for the decisions made relative to the purchase of U_3O_8 from foreign producers. With the growth of our domestic uranium industry, it is imperative that a major share of the domestic market shall be reserved for domestic producers.

May we extend our thanks to you and to the other members of the Joint Committee on Atomic Energy for the many courtesies and the consideration which has been extended to the Wyoming uranium industry. We know that every effort is being made to deal wisely with the many complex problems which confront the committee. You may be assured of full cooperation by the industry in this State.

Respectfully yours.

R. W. BEAMER, *Executive Secretary.*

YANKEE ATOMIC ELECTRIC CO.,
Boston, Mass., February 9, 1960.

HON. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Washington, D.C.

DEAR SENATOR ANDERSON: As in prior years, I should like to submit a brief report on the progress of the Yankee nuclear power project for inclusion in the record of the Joint Committee's annual section 202 hearings.

At the present time the project is nearing completion and is somewhat ahead of schedule.

During 1959 all major structural work was completed and deliveries and installation of major units of equipment were commenced. Delivery of the pressure vessel, on February 7, completed this phase and permits installation and testing of all components by midsummer. Fabrication of the initial core is proceeding on schedule and approximately half the individual fuel assemblies have been delivered for storage at the site. Our present plans call for completion of construction and loading the initial core by August of this year.

Key operating personnel are now at the plant and for the past several months have been undergoing an intensive onsite training program under the direction of the supervisory personnel responsible for operation of the plant.

To keep pace with constructtion, we now have pending before the Atomic Energy Commission a request for approval of the final design of the reactor plant, with the hearing scheduled for March 3. This will be followed by a further hearing at the time of issuance of the final operating license.

During the past year our financing program was reviewed and approved by the Massachusetts Department of Public Utilities, the Securities and Exchange Commission, and the Atomic Energy Commission. Following these approvals, Yankee's stockholder utility companies completed their investment of equity funds, which now total $20 million. Current construction costs are being financed by sales of 5-percent first-mortgage bonds and 4¾-percent bank loans pursuant to commitments which insure the availability of an aggregate of $37 million of senior funds.

Our cost experience to date indicates that our estimate of $57 million as the total financing required for the project is adequate, and in the absence of unforesen contingencies we expect to complete construction somewhat within our estimates. Any savings which may be realized in capital costs will tend to reduce the total cost of power from the plant, but because of the many variables involved we cannot now revise our estimates of total power costs, which we expect will fall within the range of 12 mills to 14 mills per kilowatt-hour after steady operation has been achieved with the second or third core. As indicated by our letter of a year ago, these power costs may be subject to later reduction as economies are achieved in various aspects of the fuel cycle, and must be measured against the steadily rising costs of constructing conventional capacity and the continuing upward trend of coal and oil prices and associated transportation costs.

Yours very truly,

WILLIAM WEBSTER, *President.*

(Whereupon, at 4:40 p.m. the committee was recessed, subject to call.)

APPENDIXES

APPENDIX 1

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., February 15, 1960.

MR. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States.

DEAR MR. RAMEY: This will acknowledge your letter of January 26, requesting information and data for inclusion in the annual section 202 hearings.

The information includes the following:

1. Highlights of activities in the civilian power reactor program, updating the information in the annual report.

2. Information on costs and schedules for civilian power reactor projects. This is presented in two arrangements. The first presents the same cost breakdowns as were used in last year's presentation. It is used for the reactors covered in last year's presentation except those completed prior to 1959 as to which any cost and schedule information we could present would be identical to that submitted last year. The second arrangement presents cost information in the cost breakdowns which are used in the quarterly construction status reports now received by the Commission for all projects on which preliminary design has begun. For projects not reported on in last year's presentation, only the second arrangement is used. An agreement has been made between our respective staffs that next year and in years following the first arrangement will be dropped and the breakdowns in the second arrangement will be used as the basis for comparison.

3. Information on fuel element development and reactor operating experiments showing—

(*a*) Utilization of fiscal years 1959 and 1960 funds for fuel cycle development.

(*b*) Narrative report on fuel element development.

(*c*) Core fabrication cost.

(*d*) Reactor operating experience with the table of test operation works for AEC civilian power reactor program estimated fiscal year 1960, as included in the fiscal year 1961 Presidential budget. Here, again, we have not attempted to repeat operating history covered in 1959 hearings, merely highlighting activities prior to 1959 and reporting any detail for the year 1959 to the date of this report.

4. Seven charts showing operating history of AEC civilian power program reactors updated to December 31, 1959.

The Chairman's testimony, which has already been submitted to you, covers in detail the other significant developments in the civilian power program.

Sincerely yours,

A. R. LUEDECKE, *General Manager.*

UPDATING OF INFORMATION IN 1959 ANNUAL REPORT ON CIVILIAN POWER REACTOR PROGRAM

Copies of the annual report for 1959 have been issued. Significant events which have taken place in the first 6 weeks of 1960 which are not recorded in the report include the following:

(1) The joint proposal of Consumers Power Co. and the General Electric Co. regarding a high power density, 50,000 electrical kilowatt boiling water prototype reactor to be built in Michigan was accepted on January 7 and contract negotiations are now underway.

(2) A two-part invitation was extended in January to utilities and reactor manufacturers for participation in a second round power demonstration reactor project incorporating a 50,000 electrical kilowatt improved cycle boiling water reactor. Proposals are to be received by April 16 from the reactor manufacturers, and by May 2 from the publicly or cooperatively owned utilities.

(3) An invitation also was extended in January under third round terms for development, design, fabrication, construction, and operation of a prototype organic cooled and moderated reactor of 50,000 electrical kilowatt capacity. Proposals are to be received by May 2.

(4) The Saxton Nuclear Experimental Corp. was issued a construction permit on February 11 for its small developmental pressurized water reactor and site work began.

(5) The Commission has selected a proposal of the Allis-Chalmers Manufacturing Co. to supply the reactor and major primary system components for the experimental low-temperature process heat reactor. The Commission has awarded the company a contract to perform detailed engineering design and has an option to purchase the reactor and primary system components from Allis-Chalmers. The proposed reactor, planned for construction in California, would be built in connection with a Department of Interior saline water conversion plant. A preliminary hazards report has been completed on a site, but the area has not yet been released by the Navy. This will delay start of construction beyond the March 1960 target date.

(6) On January 22, the homogeneous reactor experiment No. 2 was shut down after 105 continuous days of operation to investigate a marked increase in the ratio of blanket to core fuel concentration. Subsequent inspection of the interior of the reactor fuel concentration. Subsequent inspection of the interior of the reactor core revealed that a hole caused by corrosion had formed in the core tank. This new opening, measuring about ½ by 1½ inches, is about the same size as the hole found in the core tank in the autumn of 1958. The first hole was not repaired and the reactor was operated as a single region unit. While the reactor is presently shut down, it is planned to reverse the direction of the flow in the reactor and to remove the diffuser screens in order to improve the core hydrodynamics. During the course of this work, which is expected to take about 4 months, both holes will be repaired. Experimental operation for the reactor, with continued emphasis on the fuel solution stability problem, will then be resumed.

INFORMATION UPDATING COST AND SCHEDULE ESTIMATES ON CURRENT CIVILIAN REACTOR PROJECTS

This information is presented in two arrangements. The first presents the same cost breakdowns as were used in last year's presentation. It is used for those reactors covered in last year's presentation except the following projects completed prior to 1959 as to which current cost and scheduled information would be identical to that submitted last year: EBWR, SRE, HRE–2, OMRE, and BWR. The second arrangement presents cost information in the cost breakdowns which are used in the quarterly construction status reports now received by the Commission for all projects on which preliminary design has begun. For projects not reported on in last year's presentation, only the second arrangement is used. It is planned that next year and in years following the first arrangement will be dropped and the breakdowns in the second arrangement will be used as the basis for year-to-year comparisons.

It should be noted that the first method of presentation (that used last year) excludes costs for all research and development, whereas the second method includes costs for preoperational research and development.

PART I. ARRANGEMENT USED IN PRIOR YEARS

1. Shippingport Atomic Power Station, Shippingport, Pa.

	Original estimate	February 1959 estimate	Current estimate
Date of first criticality	July 1957	[1] Dec. 1957	[1] Dec. 1957.
Costs (in thousands):			
Reactor plant	$37,750	[2] $55,000	[2] $55,000
Turbine generator and transmission facilities	10,000	18,577	20,200
Total	47,750	[3] 73,577	[3] 75,200

[1] Actual.
[2] Includes first core, currently estimated at $12,700,000.
[3] Includes $5,000,000 investment by Duquesne Light Co. and a $500,000 contribution by Westinghouse Electric Corp.

2. Experimental Breeder Reactor No. 2, NRTS, Idaho

	Original estimate	February 1959 estimate	Current estimate
Date of first criticality	Mar. 1958	May 1960	Dec. 1960.
Costs (in thousands):			
Reactor and power cycle	[1] $12,000	$18,048	$16,950
Fuel fabrication	1,400	(2)	(2)
Processing plant	2,050	7,920	8,200
Site 16, NRTS	.....	3,132	3,950
Total	15,450	29,100	[3] 29,100

[1] Original estimate for reactor fabrication only.
[2] Estimates for fuel: February 1959—$1,893,000: current—$3,500,000. (This cost is not to be included in the capital cost of the plant.)
[3] An engineering estimate totaling $32,430,000 is under current review.

3. Yankee Atomic Electric Co., Rowe, Mass.

	Original estimate	February 1959 estimate	Current estimate
Date of first criticality	1958	July 1960	Sept. 1960
Costs (in thousands):			
Reactor	$16,765	$38,413	$32,460
Fuel fabrication	.....	3,600	4,000
Land, buildings, and supporting facilities	2,275	4,084	1,621
Electrical generating facilities	13,880	11,420	18,469
Total	32,920	57,517	56,550

4. Enrico Fermi Atomic Power Plant, Lagoona Beach, Mich.

	Original estimate	February 1959 estimate	Current estimate
Date of first criticality	1960	Aug. 1960	Sept. 1960
Costs (in thousands):			
Nuclear facilities	$34,300	[1] $37,020	$40,774
Fuel element fabrication	3,500	(2)	4,380
Nonnuclear facilities	10,700	14,061	14,061
Total	48,500	51,081	59,215

[1] Does not include Power Reactor Development Co. allowance of $1,175,000 for working capital, allowances for research and development expenses or plant operating costs, and waiver of fuel use charges.
[2] Included in nuclear facilities.

5. Hallam Nuclear Power Facility, Hallam, Nebr.

	Original estimate	February 1959 estimate [1]	Current estimate
Date of first criticality	1959	Nov. 1961	Mar. 1962
Costs (in thousands):			
Reactor	$13,129	$29,233	[2] $29,755
Fuel fabrication [3]	631	[3] 8,000	[3] 8,000
Nonnuclear facilities	11,350	12,965	12,276
Total	25,110	50,198	50,031

[1] February 1959 estimates, as submitted, were distributed erroneously, and are revised in this submission.
[2] An engineering estimate of $31,833,000 is under current review.
[3] 1959 and 1960 estimates for this item include extraordinary maintenance.

6. Rural Cooperative Power Association, Elk River, Minn.

	Original estimate	February 195[illegible] estimate	Current estimate
Date of first criticality	1959	Jan. 1961	Nov. 1960
Costs (in thousands):			
Reactor	$3,760	$9,383	$8,680
Fuel fabrication	([1])	([1])	717
Land, buildings, and supporting facilities	700	700	3,389
Electrical generating facility	1,725	1,818	
Total	6,185	11,901	12,786

[1] Included in cost of reactor.

7. City of Piqua, Ohio

	Original estimate	February 1959 estimate	Current estimate
Date of first criticality	1961	July 1961	May 1961
Costs (in thousands):			
Reactor	$4,010	$8,058	[1] $7,332
Fuel fabrication		1,750	[2] 2,188
Land, buildings and supporting facilities	580	1,780	1,780
Electrical generating facilities	1,031	2,175	2,175
Total	5,621	13,763	13,475

[1] Engineering estimate of $8,277,000 under current review.
[2] Engineering estimate of $990,000 under current review.

8. Northern States Pathfinder Plant, Sioux Falls, S. Dak.

	February 1959 estimate [1]	Current estimate
Date of first criticality	August 1962	June 1962
Costs (in thousands):		
Reactor	$12,190	$10,275
Fuel fabrication	([2])	950
Land, buildings, and supporting facilities	3,560	2,155
Electrical generating facilities	5,850	10,230
Total	21,600	23,610

[1] First estimate submitted.
[2] Included in cost of reactor.

9. Florida West Coast Reactor, Pierce, Fla.

	February 1959 estimate [1]	Current estimate
Date of first criticality	June 1963	June 1963.
Costs (in thousands):		
Reactor	$10,585	$8,060
Fuel fabrication	([2])	1,200
Land, nonnuclear and supporting facilities	15,300	21,887
Total	25,885	31,147

[1] First estimate submitted.
[2] Included in cost of reactor.

10. Carolinas-Virginia Nuclear Power Associates, Parr, S.C.

	February 1959 estimate [1]	Current estimate
Date of first criticality	June 1962	July 1962.
Costs (in thousands):		
Reactor	$18,141	$20,100
Fuel fabrication	1,000	1,180
Land		90
Total	19,141	21,370

[1] First estimate submitted.

Privately financed projects

	Construction essentially complete			Estimated cost (in millions)		
	Original estimate	Feb. 1959 estimate	Current estimate	Original estimate	Feb. 1959 estimate	Current estimate
Consolidated Edison thorium reactor, Indian Point, N.Y.	1960	1960	Nov. 1960	$55.0	$90	$96.6
Saxton nuclear experimental reactor, Liberty, Pa	1961	([1])	Oct. 1961	[2] 6.2	([1])	[2] 6.2
Commonwealth Edison Dresden nuclear power station, Morris, Ill	1960	1959	Sept. 1959 [3]	45.0	45	46.4
Pacific Gas & Electric Humboldt Bay project, Humboldt, Calif	1962	([1])	May 1962	19.5	([1])	22.1

[1] Original estimate not available until after February 1959.
[2] Fixed price for turnkey nuclear facility includes R. & D. program, fuel fabrication, processing and burnup and inventory charges for 5 years of operation.
[3] Actual.

PART II. REVISED ARRANGEMENT OF DATA

Estimated total cost and scheduled information

I. AEC EXPERIMENTAL CIVILIAN POWER PROJECTS

	National Reactor Testing Station, Idaho			Oak Ridge, Tenn.	Los Alamos, N. Mex.	
	Borax V	EBR II	EOCR	EGCR	HTGRE TURRET	LAMPRE I
A. Costs (in thousands):						
1. Preoperational research and development	$775	$27,500	----------	$32,115	$1,000	$968
2. Land and land rights	----------	----------	----------	----------	----------	----------
3. Plant and equipment	1,530	29,100	$6,000	30,700	4,662	607
4. Fuel fabrication	637	3,500	123	1,500	5,000	251
5. Total	2,942	60,100	6,123	64,315	10,662	1,826
B. Schedule information:						
1. First criticality	Jan. 1961	Dec. 1960	May 1962	Nov. 1962	Feb. 1962	Nov. 1959
2. First operation at design power	Mar. 1961	Apr. 1961	July 1962	Jan. 1963	May 1962	July 1960

II. POWER DEMONSTRATION REACTOR PROGRAM—1ST AND 2D ROUNDS

	Yankee Atomic Electric Co., Rowe, Mass.	Enrico Fermi Atomic Power Plant, Lagoona Beach, Mich.	Hallam Nuclear Power Facility, Hallam, Nebr.	Rural Cooperative Power Association, Elk River, Minn.	City of Piqua, Ohio
A. Costs (in thousands):					
AEC costs:					
1. Preoperational research and development	$5,000	$4,450	$18,165	----------	$3,500
2. Land and land rights	----------	----------	----------	----------	----------
3. Plant and equipment	----------	----------	24,013	$8,680	7,332
4. Fuel fabrication	----------	----------	8,000	717	2,188
5. Total AEC costs	5,000	4,450	50,178	9,397	13,020
Non-AEC costs:					
6. Preoperational research and development	450	19,017	----------	----------	----------
7. Land and land rights	200	882	----------	----------	----------
8. Plant and equipment	52,350	53,953	18,018	3,389	3,955
9. Fuel fabrication	4,000	4,380	----------	----------	----------
10. Total non-AEC costs	57,000	78,232	18,018	3,389	3,955
Total costs:					
11. Preoperational research and development	5,450	23,467	18,165	----------	3,500
12. Land and land rights	200	882	----------	----------	----------
13. Plant and equipment	52,350	53,953	42,031	12,069	11,287
14. Fuel fabrication	4,000	4,380	8,000	717	2,188
15. Total	62,000	82,682	68,196	12,786	16,975
B. Schedule information:					
1. First criticality	Sept. 1960	Sept. 1960	Mar. 1962	Nov. 1960	May 1961
2. First operation at design power	Nov. 1960	June 1961	May 1962	Feb. 1961	June 1961

Estimated total cost and scheduled information

III. POWER DEMONSTRATION REACTOR PROGRAM—3D ROUND

	Northern States Power Co., Sioux Falls, S. Dak.	Carolinas-Virginia Nuclear Power Association, Parr, S.C.	Florida West Coast Reactor, Pierce, Fla.	Philadelphia Electric Co., Peach Bottom, Pa.
A. Costs (in thousands):				
AEC costs:				
1. Preoperational research and development	$7,500	$10,146	$8,646	$12,500
2. Land and land rights				
3. Plant and equipment				
4. Fuel fabrication				
5. Total AEC costs	7,500	10,146	8,646	12,500
Non-AEC costs:				
6. Preoperational research and development	4,200	190	10,519	4,121
7. Land and land rights	400	90	317	250
8. Plant and equipment	18,010	20,100	30,315	25,800
9. Fuel fabrication	950	1,180	515	1,510
10. Total non-AEC costs	23,610	21,560	41,666	31,681
Total costs:				
11. Preoperational research and development	11,700	10,336	19,165	16,621
12. Land and land rights	450	90	317	250
13. Plant and equipment	18,010	20,100	30,315	25,800
14. Fuel fabrication	950	1,180	515	1,510
15. Total	31,110	31,706	50,312	44,181
B. Schedule information:				
1. First criticality	June 1962	July 1962	June 1963	Dec. 1963
2. First operation at design power	Oct. 1962	Nov. 1962	[1]	[2]

[1] Not available.
[2] Early 1964.

INFORMATION ON FUEL ELEMENT DEVELOPMENT AND REACTOR OPERATING EXPENSES

A. Utilization of Fiscal Year 1959 and 1960 Funds for Fuel Cycle Development

	Fiscal year 1959 actual	Fiscal year 1960 estimate
Chicago Operations Office:		
AmesLaboratory	378	385
Atomics International	1,355	900
Bureau of Mines	311	300
Battelle Memorial Institute	659	895
Denver Research	16	55
Subtotal	2,719	2,535
New York Operations Office:		
Babcock & Wilcox	0	173
Nuclear Metals	483	525
Martin Co	131	65
Combustion Engineering	61	564
Nuclear Development Corp. of America	105	454
Nuclear Materials & Equipment Corp	11	1,275
Rensselaer Polytechnic Institute	162	200
Sanderson & Porter	36	441
Stevens Institute	45	75
Sylvania Corning	200	250
Arthur D. Little, Inc	0	60
Materials Research Corp	25	28
Aeroprojects, Inc	0	38
Olin-Mathieson	24	250
Vitro Manufacturing Co	38	0
Metal Hydrides	14	0
Owens Corning	0	100
Technical Research Group	9	43
Westinghouse	0	687
Subtotal	1,344	5,228
Oak Ridge operations office:		
Oak Ridge National Laboratory	1,180	679
Clevite	9	80
Carborundum	8	75
Georgia Institute of Technology	75	180
Union Carbide Metals	10	150
National Carbon Co	12	210
Subtotal	1,294	1,374
San Francisco operations office:		
General Electric Co	36	1,168
General Atomic	70	440
American Standard	72	342
Gladding McVean	10	28
Aerojet General	10	12
Subtotal	198	1,990
Idaho operations office: Phillips Petroleum	349	0
Subtotal	349	0
Washington headquarters:		
Bureau of Standards	20	40
Unassigned	0	[1] 1,833
Subtotal	20	1,873
Total	5,924	13,000

[1] Contract actions pending.

NOTE.—No estimate is provided for fiscal year 1961 since the fuel cycle program is being merged with base programs in nuclear technology.

B. Fuels and Materials Development

Present nuclear power costs can be substantially reduced by the development of reactor fuels capable of operating at high energy output and elevated temperatures over extended time periods. Advanced research and development on fuel element materials will also contribute significantly to the production of lower cost, more efficient reactor fuel cores. Current fuel element manufacturing costs may also be lowered by utilization of new and improved fabrication techniques.

Accelerated efforts are in progress both on obtaining basic data for reactor fuels and the effective development, fabrication, testing, and operation of specific reactor fuel element types. The fuel cycle development program, initiated to intensify the effort to develop more economical reactor fuel cycles for power reactors, is being integrated with the basic research program on fuels and materials designed to provide a general source of technology for improvement of power reactor fuels. The current status of the various fuel element concepts within the power reactor program is outlined in table 1.

As shown in the table, emphasis continues in nuclear fuel element development on the use of UO_2, alone or combined with ThO_2 as a fertile diluent. Metallic uranium and its alloys, which are easier to fabricate and possess higher thermal conductivity than UO_2, are dimensionally unstable under irradiation at temperatures above 450° C. Gaseous fission products released during fuel operation cause massive swelling in metallic fuels above this temperature. UO_2 is more compatible with water than are metallic fuels which enhances its use in water reactors. Stability of UO_2 under irradiation and its compatibility with cladding materials, such as stainless steel, aluminum alloys, and zirconium alloys, are important advantages over metallic fuels.

Fuel element technology now being used to fabricate UO_2 fuel elements consists primarily of the production of UO_2 pellets by pressing, sintering, and grinding, followed by insertion into metallic tubes. Other techniques for the production of UO_2 fuel assemblies are being studied intensively. Processing that would reduce manufacturing costs are the fabrication of tubes containing UO_2 powder into fuel rods by cold or hot swaging, isostatic pressing or vabratory compaction, or coextrusion of the oxide core and cladding. These techniques, if successful, would achieve significant reductions in costs by eliminating the close dimensional tolerances of the pellet and tube now required in order to achieve the controlled spacing necessary for efficient heat transfer.

Significant results from irradiation tests indicate that uranium carbide may be used as a fuel for metal-cooled and gas-cooled nuclear reactors. Uranium carbide has been irradiated to 13,000 MWD/T burnup at temperatures ranging from 1,300° to 1,600° F., with a volume increase of only 2 percent. These results are very encouraging. Extensive investigations of uranium carbide production, physical and mechanical properties, and compatibility with claddings over an extended temperature range are being pursued. A core loading of UC fuel for Hallam is planned as part of the Hallam project research and development program.

Metallic uranium alloy fuel elements with stainless steel or zircaloy 2 cladding have been fabricated. Zircaloy 2 clad U–10 percent Mo fuel elements are being fabricated for the PRDC reactor and zircaloy 2 clad U–5 percent Zr–1.5 percent Nb elements were utilized in the EBWR. The addition of Mo to U increases the strength of the alloy and improves the thermal and irradiation stability. The U–5 percent Zr–1.5 percent Nb alloy is resistant to water corrosion and has improved strength, thermal, and irradiation stability over metallic U. These alloys can be expected to perform satisfactorily at 650° C. in the case of U–Mo and 290° C. in the case of U–5 Zr–1.5 Nb but with a much lower allowable burnup than can be tolerated with UO_2 fuel elements before distortion becomes excessive.

A systematic research and development effort is underway to determine the machanism which produces swelling of uranium under radiation. A technique for inhibiting such growth may be developed through understanding the conditions and environments under which fission products in uranium nucleate and grow. This investigation coupled with the use of high strength cladding to restrain swelling and the search for radiation resistant fissionable alloys may eventually allow increased use of metallic fuels.

Final selection of fuel composition for the fast reactor, EBR–2 has been made. This alloy is metallic uranium with 5 to 10 percent fissium (an equilibrium fission product alloy) with 1 percent to 5 percent Zr. These alloys have been found to be resistant to irradiation damage and it is anticipated that 1 to 2 atomic percent burnup can be achieved. The cross section of these materials for capture of thermal neutrons makes this alloy unattractive for thermal reactors.

Continued attention to the problem of providing improved fuel element cladding has resulted in significant progress. A zirconium alloy (zircaloy No. 4) has been developed in the naval reactors program in support of the Shippingport pressurized water reactor at the Bettis Laboratory. This alloy is more resistant to hydrogen embrittlement under conditions encountered in water reactors than previously available zirconium alloys. An oxidation resistant iron-aluminum alloy which has a lower neutron capture cross section than stainless steel is being seriously considered for use in gas-cooled reactors. Refactory alloys of Nb are under development for service in reactors cooled by circulating alkali metals. The problems of welding and fabricating aluminum alloys prepared by sintering preoxidize aluminum powder are being solved in anticipation of using these materials as fuel element cladding in organic moderated reactors.

The increased effort on the development of gas-cooled nuclear reactors has led to the initiation of research investigations to provide basic engineering data on graphite matrix fuel element materials incorporating either UO_2 or UC as the nuclear fuel. These basic studies supplement a continued effort to develop refractory coatings for graphite which are resistant to thermal and mechanical shock and which will prevent the release of fission gases. Several such coatings have been developed independently by industrial concerns and others have been developed under Government sponsorship. Sample spherical fuel elements with these protective coatings have been evaluated at temperature under irradiation. The more promising of these claddings will be subjected to further evaluation at higher temperatures and at higher irradiation levels.

TABLE 1.—*Power reactor fuel elements, February 1960*

Project	Reactor type	Fuel type	Cladding	Core status
Yankee	Pressurized H_2O	UO_2	Stainless steel	Fabrication and delivery in process.
Pathfinder	Boiling H_2O	UO_2	Al–Ni	R. & D.
Dresden	do	UO_2	Zircaloy 2	Delivery complete.
Kaiser-AFC	Gas cooled	UO_2	Stainless steel	R. & D.
PRTR [1]	Pressurized D_2O	UO_2 and Pu–Al	Zircaloy 2	Fabrication.
CVNPA [2]	do	UO_2	do	R. & D.
PWR	Pressurized H_2O	UO_2	do	Operating (see 1 being replaced).
OMRE	Organic moderated	UO_2	Stainless steel	Operating.
EOCR	do	UO_2	do	Design.
			Sintered aluminum	
Florida	Gas cooled	UO_2	Stainless steel	R. & D.
Elk River	Boiling H_2O	ThO_2–UO_2	do	Fabrication.
Borax	do	ThO_2–UO_2	Al–Ni	Cooling and examination.
Indian Point	Pressurized H_2O	ThO_2–UO_2	Stainless steel	Design.
EBWR	Boiling H_2O	U–Zr–Nb	Zr–2	Operating (28 5-foot spikes being fabricated).
EBR–1	Fast breeder	U–Zr	Zircaloy 2	Operating.
HWCTR	Pressurized D_2O	U–Zr	do	R. & D. and preliminary fabrication.
PRDC	Fast breeder	U–Mo	Zirconium	Fabrication.
Hallam	Sodium graphite	U–Mo	Stainless steel	Design.
Piqua	Organic moderated	U–Mo	Al	Do.
EBR–II	Fast breeder	Fissium	Stainless steel	R. & D.
SRE	Sodium graphite	U	do	Down for repairs.
		U–th	do	Fabricated.
HTGR	Gas cooled	UC–ThC in C	First core stainless steel; 2d core, unclad.	R. & D.
EGCR	do	UO_2	Stainless steel	R. & D.

[1] Natural U with Pu–Al alloy spike elements.
[2] Will probably be hollow pellets with high melting ceramic cores.

Reactor Operating Experience

(Including operational costs)

The Commission submitted for last year's hearings narrative, tabular, and chart material on experience with the operation of all U.S. civilian power reactors then in being. This material was reproduced on pages 497–509 of the printed hearings.

Information on further operating experience achieved during the year 1959 is contained in the Commission's annual report, already submitted to Congress, as follows:

Reactor:	*Page in annual report*
Shippingport Atomic Power Station (PWR)	16–17
Experimental boiling water reactor (EBWR)	20
Vallecitos boiling water reactor (VBWR)	20–21
Organic moderated reactor experiment (OMRE)	24–25
Sodium reactor experiment (SRE)	27–28
Homogeneous Reactor Experiment No. 2 (HRE–2)	32
Los Alamos Power Reactor Experiment No. 2 (LAPRE–2)	32–33
Experimental Breeder Reactor No. 1 (EBR–1)	33–34

Information on still more recent operating experience, that achieved during the first 6 weeks of 1960, is contained in the first report in this appendix under the heading, "January 1960 Supplement to the Annual Report."

Information updating the table on core fabrication costs, included in last year's print on page 496, is as follows:

Core fabrication costs

	Thousands
Pressurized water reactor, seed No. 2	$3,000
Pressurized water reactor, seed No. 3	3,700
Pressurized water reactor, core No. 2	14,000
Experimental boiling water reactor:	
Core 1A (U–spikes)	321
Core 1B (Pu–spikes)	100
Core 2	1,300
BORAX V, core No. 1	917
Experimental breeder reactor I: Core 4	200
Experimental breeder reactor II:	
Core I	3,269
Core 1A (Pu elements)	250
Core 1B (replacement of fuel elements)	300
Organic moderated reactor experiment:	
Core 2	254
Core 3	506
Plutonium recycle test reactor:	
Core 1	800
Core 1 (replacement fuel elements)	725
Heavy water components test reactor: Core No. 1	600
Sodium reactor experiment:	
Core 2	514
Core 3	655

Information updating the table on operating costs, included in last year's print on page 502, is shown below:

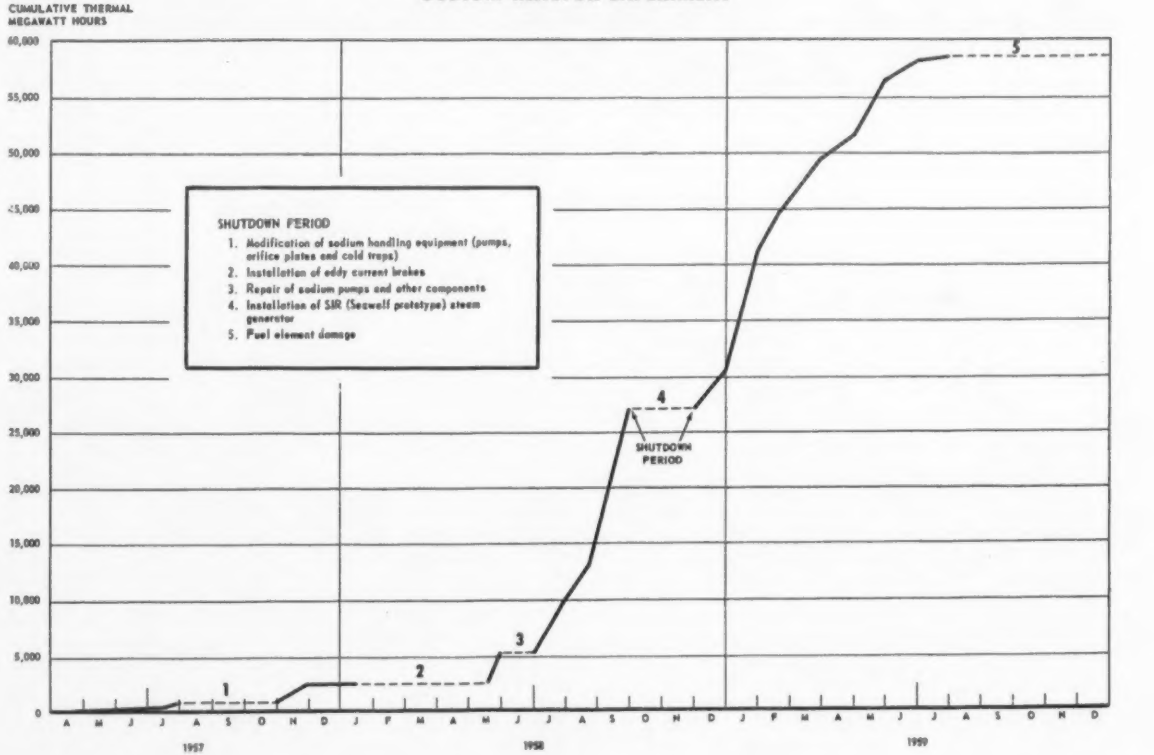
Fiscal year 1960 estimated test operation costs for AEC civilian power reactor program as included in the fiscal year 1961 Presidential budget[1]

Reactor:	*Cost*
Shippingport Atomic Power Station (PWR)	$2,150,000
Experimental boiling water reactor (EBWR)	300,000
Boiling reactor experiment No. 5 (Borax–5)	500,000
Homogeneuos reactor experiment No. 2 (HRE–2)	2,000,000
Experimental breeder reactor No. 1 (EBR–1)	1,100,000
Sodium reactor experiment (SRE)	1,400,000
Organic moderated reactor experiment (OMRE)	960,000

[1] Excludes all R. & D. and fuel costs.

OPERATING HISTORY OF AEC CIVILIAN POWER PROGRAM REACTORS

SODIUM REACTOR EXPERIMENT



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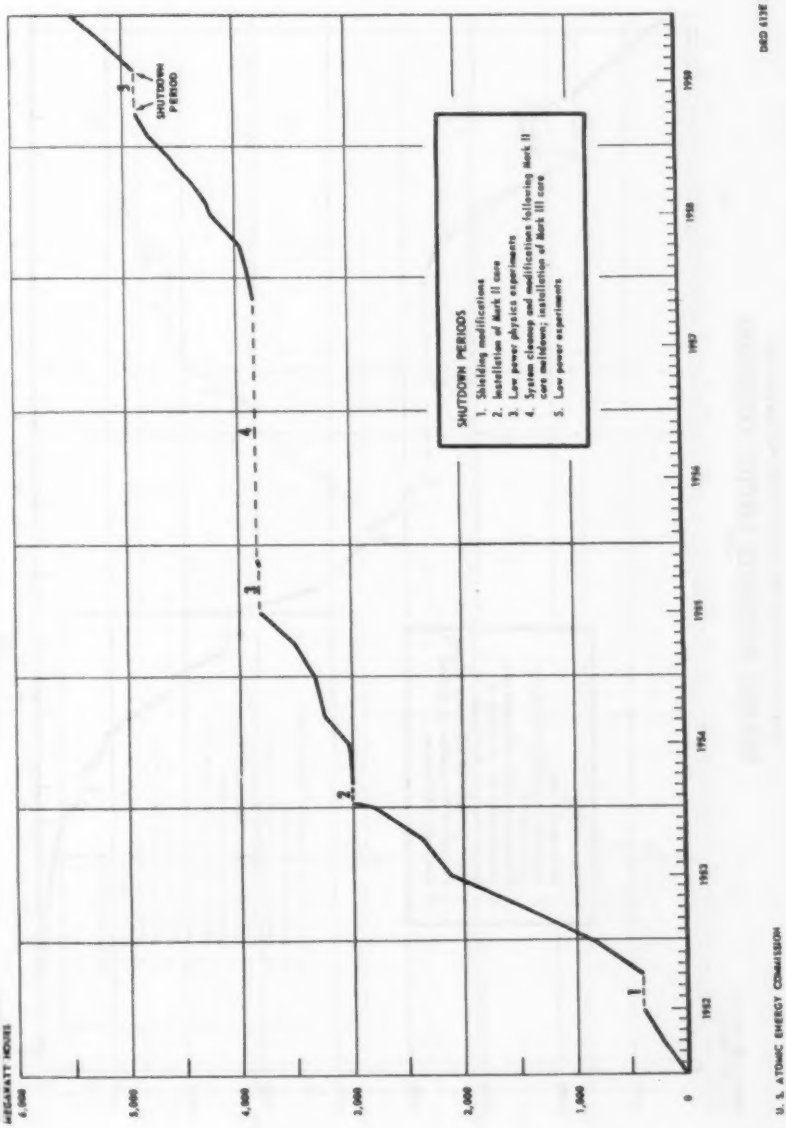
OPERATING HISTORY OF AEC CIVILIAN POWER PROGRAM REACTORS

EXPERIMENTAL BREEDER REACTOR No. 1

CUMULATIVE THERMAL



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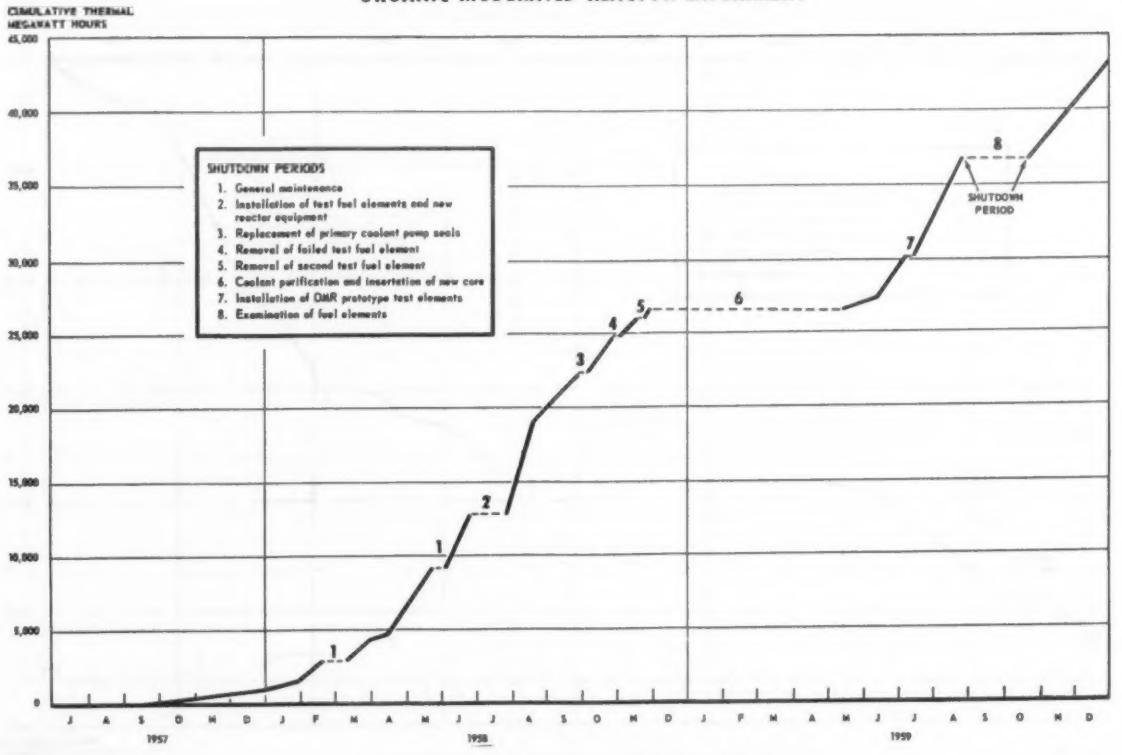
OPERATING HISTORY OF AEC CIVILIAN POWER PROGRAM REACTORS

ORGANIC MODERATED REACTOR EXPERIMENT



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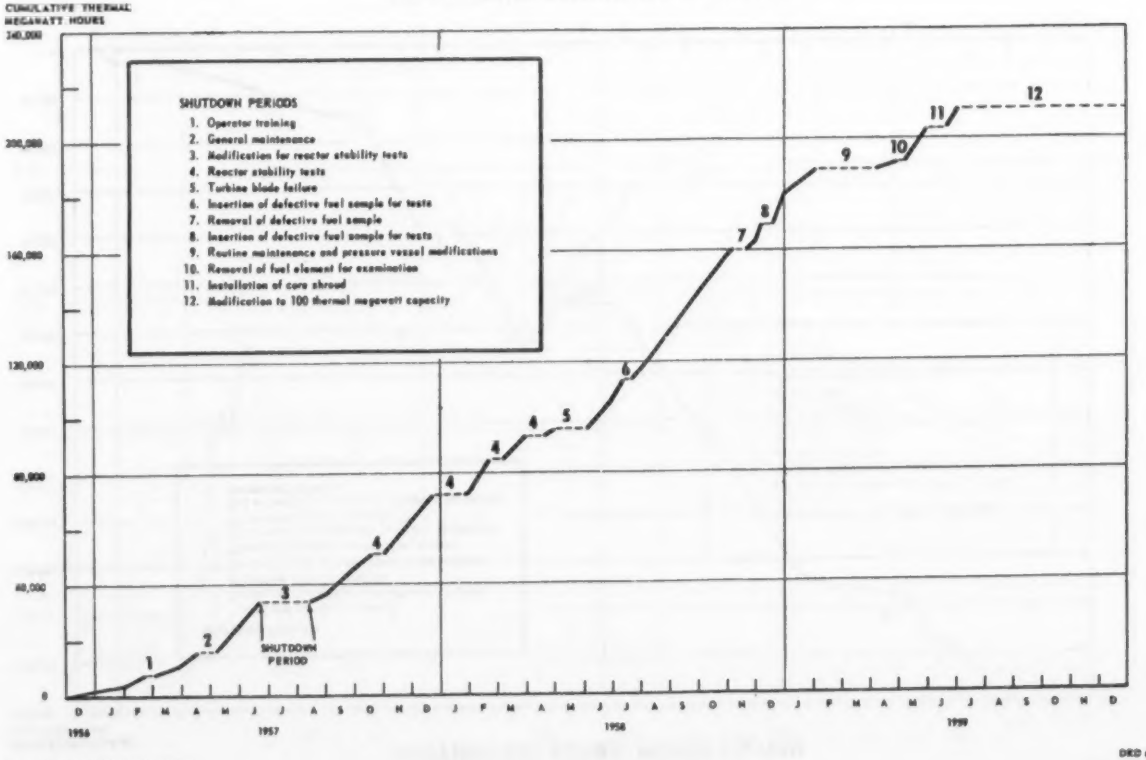
OPERATING HISTORY OF AEC CIVILIAN POWER PROGRAM REACTORS

EXPERIMENTAL BOILING WATER REACTOR

OPERATING HISTORY OF AEC CIVILIAN POWER PROGRAM REACTORS

EXPERIMENTAL BOILING WATER REACTOR



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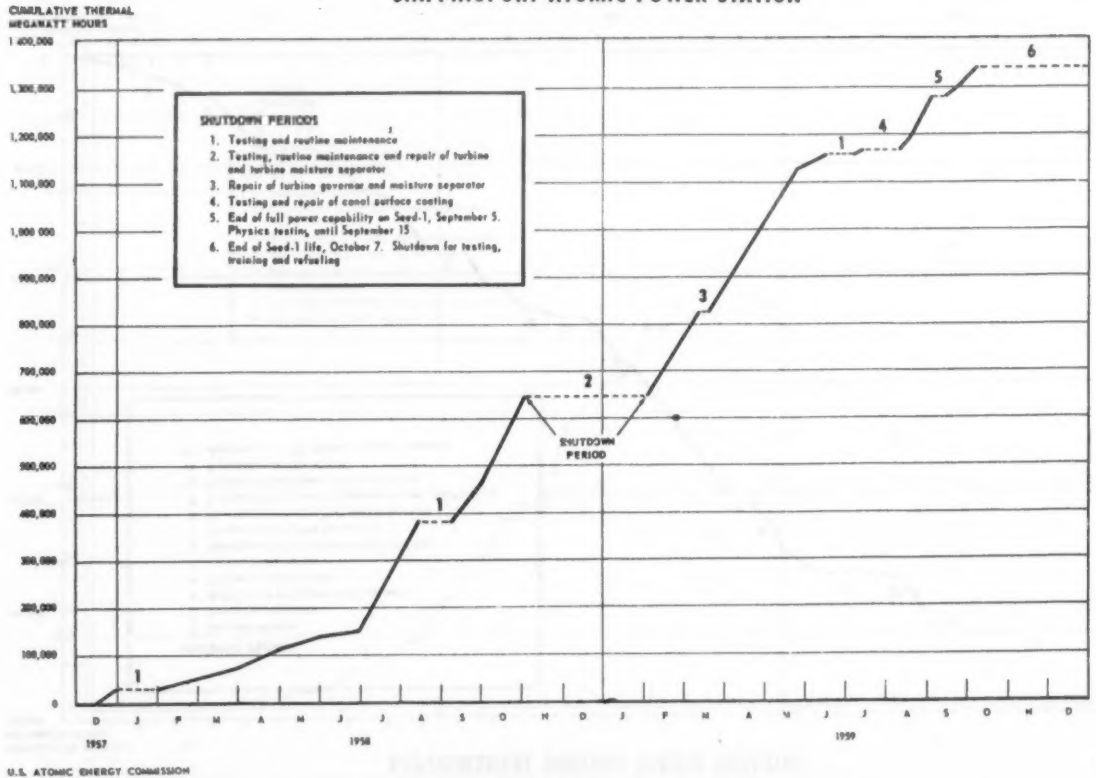
OPERATING HISTORY OF AEC CIVILIAN POWER PROGRAM REACTORS

SHIPPINGPORT ATOMIC POWER STATION



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OPERATING HISTORY OF AEC CIVILIAN POWER PROGRAM REACTORS

BOILING REACTOR EXPERIMENTS No. 2 AND No. 4

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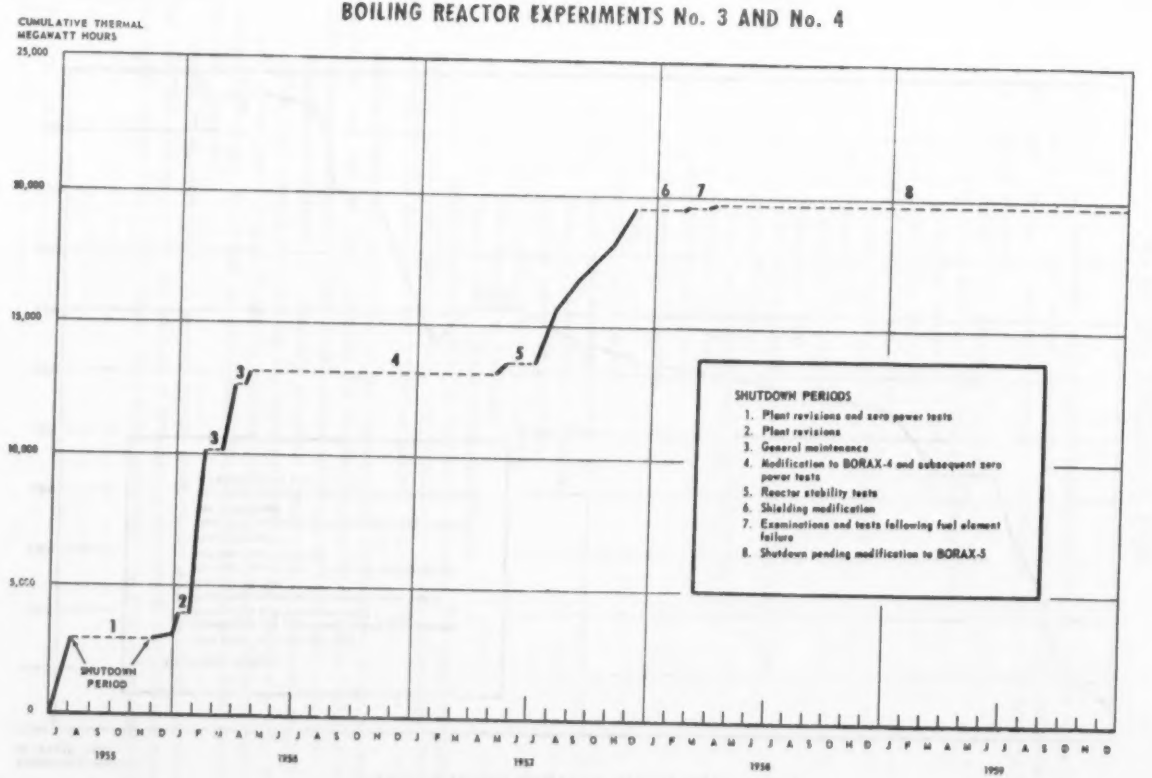
OPERATING HISTORY OF AEC CIVILIAN POWER PROGRAM REACTORS

BOILING REACTOR EXPERIMENTS No. 3 AND No. 4



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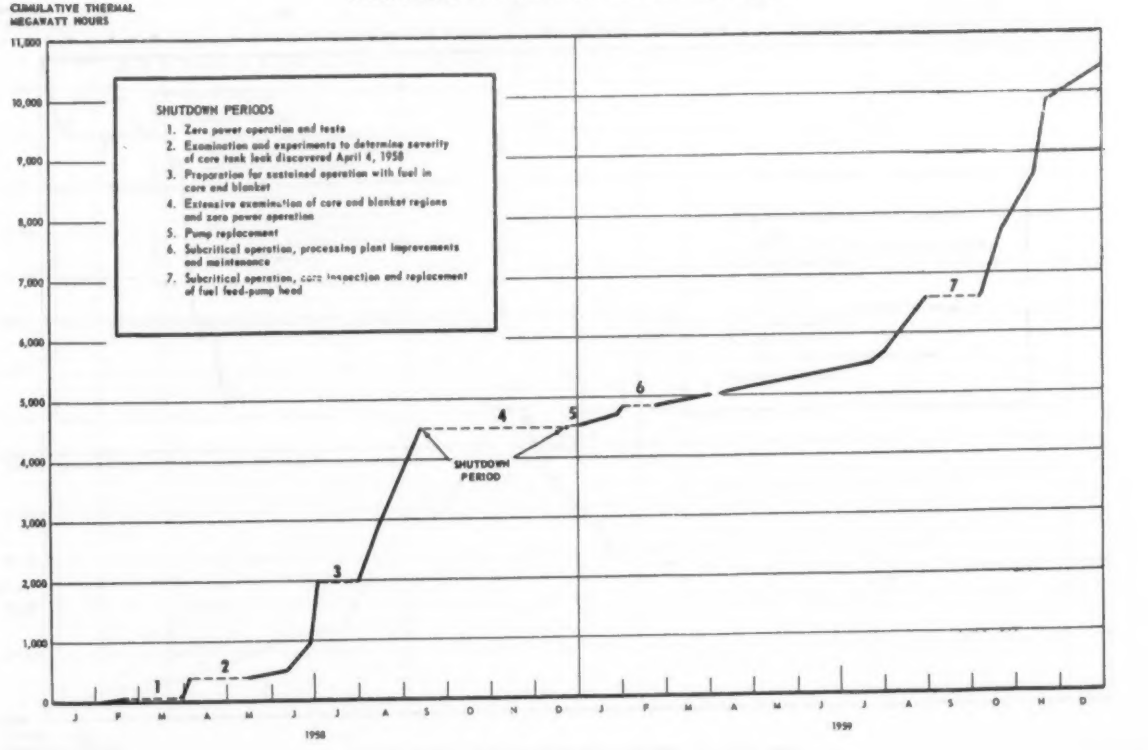
OPERATING HISTORY OF AEC CIVILIAN POWER PROGRAM REACTORS

HOMOGENEOUS REACTOR EXPERIMENT No. 2



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APPENDIX 2

NUCLEAR REACTORS BUILT, BUILDING, OR PLANNED IN THE UNITED STATES AS OF DECEMBER 31, 1959

This compilation contains information about facilities built, building, or planned in the United States as of December 31, 1959, which are capable of sustaining a nuclear chain reaction. Certain experiments relating to military systems are included but are not listed in detail because of their classified nature.

The material is presented in the following sequence:

- A. CIVILIAN POWER AND PROPULSION REACTORS
  - A.1 Stationary Power, U. S. Locations
  - A.2 Propulsion (Maritime)
- B. OTHER CIVILIAN REACTORS
  - B.1 Reactor Experiments, U. S. Locations
  - B.2 General Test
  - B.3 Research and Training
  - B.4 Specialized Test
- C. MILITARY PROPULSION, POWER, AND TEST REACTORS
  - C.1 Naval Propulsion
  - C.2 Prototypes, Experiments, and Field Plants
  - C.3 Research and Test
- D. PRODUCTION REACTORS
  - D.1 Materials Production
  - D.2 Test
- E. REACTORS FOR EXPORT
  - E.1 Stationary Power
  - E.2 Research, Training, and Testing
  - E.3 Critical Assembly Facilities
- F. CRITICAL ASSEMBLY FACILITIES
  - F.1 Identification of Facilities
  - F.2 Identification of Experiments and Studies

The reactors are categorized primarily by function or purpose. The major categories—civilian, military, production, export, power, and propulsion—are self-explanatory. Various reactor types within these categories are defined as follows:

REACTOR EXPERIMENT A reactor in the research and development program, usually producing less than 10 Mw(t), designed for the limited purpose of testing technical feasibility of a reactor concept or some unique reactor feature or piece of equipment. (Sec. B.1)

EXPERIMENTAL REACTOR A relatively complete reactor plant designed, engineered, constructed, and operated to provide the technical basis for the design of a large-scale nuclear power plant. Design flexibility permits changes to prove-out different aspects of reactor technology. Electrical or power generation may or may not be included as part of the plant. (Sec. B.1)

PROTOTYPE REACTOR PLANT A nuclear power plant of any size designed, constructed, and operated principally for the purpose of proving-out economical and technical aspects of a future commercial nuclear power plant of the same type. The generation of significant

U. S. ATOMIC ENERGY COMMISSION

quantities of electricity, mechanical power, or process heat is usually a function of such a plant. (Secs. A.1 and A.2)

COMMERCIAL REACTOR PLANT A nuclear facility constructed and operated under a license issued under Section 103 of the Atomic Energy Act of 1954 and capable of producing steam for the generation of electricity, propulsion, and space or process heat applications at costs as low as a nonnuclear plant built at the same site. (No reactors presently in the category)

GENERAL TEST REACTOR The general-test-reactor category includes only those reactors having (1) a thermal output of 10,000 kw or more; (2) test loops or experimental facilities within, or in close proximity to, the core; and (3) the use of nuclear radiation for testing the life or performance of reactor components as its major function. (Sec. B.2)

SPECIAL TEST REACTOR A reactor which is in general an integral part of a test performance which has kinetic or short-duration high power excursion or which is designed for special testing purposes. (Sec. B.4)

RESEARCH REACTOR Any reactor whose nuclear radiations are used primarily as a research tool for basic or applied research regardless of operating power level. May include facilities for testing reactor materials. (Sec. B.3)

TRAINING REACTOR Any reactor operated for the primary purpose of training in the operation and utilization of reactors and for instruction in reactor theory and performance. Thermal power level is arbitrarily limited to 10 kw. (Sec. B.3)

CRITICAL FACILITY A reactor capable of sustaining a nuclear chain reaction and designed to test at extremely low power (a few watts) a critical mass, neutron flux distribution, and other characteristics of flexible arrangement of nuclear fuel, materials of construction, coolant, and other reactor components. Fluid critical facilities are used to explore the critical masses of various concentrations of solutions in differing geometries. Metal critical assemblies are used to investigate the variations in heterogeneous cores. (Sec. F)

The abbreviated listings in the principal-contractor column refer to the technical organization assigned primary responsibility for design and/or fabrication of the reactor system. The spelled-out forms for these abbreviations, as well as those for designers, shipbuilders, and facility operators, are given preceding the table.

Start-up dates refer to the year of first criticality. Estimated dates for projects not yet in service, based on the best available information, are included. The dates for non-Commission projects are estimates announced by the sponsoring organizations.

Reactors are listed as being operable under the following circumstances:

1. Federal Government reactors — when criticality is achieved.
2. Non-Federal Government reactors in the United States — when an operating license is issued by the Commission.
3. Reactors for foreign locations — when criticality is achieved.

Reactors are listed as being built under the following circumstances:

1. Federal Government reactors — when ground is broken, components ordered, or contract awarded, whichever is first.
2. Non-Federal Government reactors in the United States — when the construction permit is issued by the Commission.
3. Reactors for foreign locations — when an application for an export license is received by the Commission or when reliable information is received relating to the fabrication of reactor components.

Reactors are listed in the planned category under the following circumstances:

1. Federal Government reactors — when publicly announced or development work started.
2. Non-Federal Government reactors in the United States — when license application is received by the Commission, or a public announcement which includes principal contractor and reactor type is made, whichever is first.
3. Reactors for foreign locations — when public announcement that includes principal contractor and reactor type is made or when the Commission receives information that a U. S. reactor manufacturer is proceeding with preconstruction design and development on the basis of a letter of intent.

LIST OF CONTRACTORS, DESIGNERS, SHIPBUILDERS, AND FACILITY OPERATORS FOR WHICH ABBREVIATIONS APPEAR IN TABLES

AC	Allis-Chalmers Mfg. Co.
ACF	ACF Industries, Inc. (Absorbed by AC)
AG	Aerojet-General Corporation
AGN	Aerojet-General Nucleonics, a Subsidiary of Aerojet-General Corporation
AI	Atomics International, a Division of North American Aviation, Inc.
Alco	Alco Products, Inc.
AMF	AMF Atomics, Inc., a Division of American Machine & Foundry Co.
ANL	Argonne National Laboratory, operated by the University of Chicago
ANPD	Aircraft Nuclear Propulsion Department, General Electric Company
ARSS	American Radiator & Standard Sanitary Corp.
BAC	Bendix Aviation Corp.
Bethlehem	Shipbuilding Division, Bethlehem Steel Co.
BNL	Brookhaven National Laboratory, operated by Associated Universities, Inc.
B&W	The Babcock & Wilcox Co.
CE	Combustion Engineering, Inc.
CL	Clinton Laboratory of the Manhattan Engineering District
Convair	Convair Division, General Dynamics Corp.
Cook	Nucledyne Corp. of Chicago, a Division of Cook Electric Company
CW	Curtiss-Wright Corporation
Daystrom	Daystrom, Inc.
du Pont	E. I. du Pont de Nemours & Company
Elec. Boat	Electric Boat Division, General Dynamics Corp.
Fluor	The Fluor Corporation, Ltd.
FW	Foster Wheeler Corp.
GDC	General Atomic Division, General Dynamics Corp.
GE	General Electric Company
GNE	General Nuclear Engineering Corp., a Subsidiary of Combustion Engineering, Inc.
HKF	H. K. Ferguson Co.
Ingalls	Ingalls Shipbuilding Corp.
KE	Kaiser Engineers, a Division of Henry J. Kaiser Co.
LASL	Los Alamos Scientific Laboratory, operated by the University of California
Lockheed	Lockheed Aircraft Corp.
Mare Island	Mare Island Naval Shipyard
Martin	Martin Co.
Maxon	Maxon Construction Company, Inc.
Met. Lab	Metallurgical Laboratory of the Manhattan Engineering District

NASA	National Aeronautics and Space Administration
NDA	Nuclear Development Corp. of America
Newport News	Newport News Shipbuilding & Dry Dock Co.
NRL	Naval Research Laboratory
NYSC	New York Shipbuilding Corp.
ORNL	Oak Ridge National Laboratory, operated by Union Carbide Nuclear Company, a Division of Union Carbide Corporation
Portsmouth	Portsmouth Naval Shipyard
PPC	Phillips Petroleum Co.
P&W	Pratt & Whitney Aircraft Division, United Aircraft Corp.
Sandia	Sandia Laboratory, operated by Sandia Corp., a Subsidiary of Western Electric Co.
SL	Sargent & Lundy
UCLRL	University of California Lawrence Radiation Laboratory
West	Westinghouse Electric Co.
Vitro	Vitro Engineering Division, Vitro Corporation of America

A. CIVILIAN POWER AND PROPULSION REACTORS

A.1 Stationary Power, U. S. Locations

Name and/or owner	Location	Principal nuclear contractor	Type	Power[1] Net kw(e)	Power[1] Kw(t)	Start-up
OPERABLE						
Shippingport Atomic Power Station (AEC and Duquesne Light Co.)[2]	Shippingport, Pa.	West	Pressurized water	60,000	231,000	1957
Dresden Nuclear Power Station (Commonwealth Edison Co.)	Morris, Ill.	GE	Boiling water	180,000	626,000	1959
BEING BUILT						
Consolidated Edison Thorium Reactor[3]	Indian Point, N. Y.	B&W	Pressurized water	255,000	795,000	1961
Enrico Fermi Atomic Power Plant (Power Reactor Development Co.)[4]	Lagoona Beach, Mich.	Owner	Fast breeder	94,000	304,000	1960
Yankee Atomic Electric Co.[5,6]	Rowe, Mass.	West	Pressurized water	110,000	392,000	1960
AEC and Rural Cooperative Power Association[5,7]	Elk River, Minn.	AC	Boiling water	22,000	73,000	1961
Hallam Nuclear Power Facility, Sheldon Station (AEC and Consumers Public Power District)[5]	Hallam, Nebr.	AI	Sodium graphite	75,000	254,000	1962
AEC and City of Piqua, Ohio[5]	Piqua, Ohio	AI	Organic moderated	11,400	45,500	1961
PLANNED						
Northern States Power Co. Pathfinder Plant[5,8]	Sioux Falls, S. Dak.	AC	Boiling water	62,000	203,000	1962
Carolinas-Virginia Nuclear Power Associates, Inc.[5]	Parr, S. C.	West	Pressure tube, heavy water	17,000	60,500	1962
Humboldt Bay Power Plant, Unit No. 3 (Pacific Gas and Electric Co.)	Humboldt Bay, Calif.	GE	Boiling water	47,500	163,000	1962
Consumers Power Company[9]	Big Rock Point, Mich.	GE	Boiling water	50,000		1962
Small Size Nuclear Power Plant (AEC and undetermined utility organization)			Pressurized water	22,000	61,000	1962
East Central and Florida West Coast Nuclear Groups[5]	Florida	GNE	Gas cooled, heavy water moderated	50,000	153,400	1963
Philadelphia Electric Co.[5,10]	Peach Bottom, Pa.	GDC	Gas cooled, graphite moderated	28,500	92,000	1963
Improved Cycle Prototype Boiling Water Reactor (AEC and undetermined utility organization)			Boiling water	50,000		
Boiling Reactor Nuclear Superheat Project (AEC and Puerto Rico Water Resources Authority)				16,300		
Organic Cooled Reactor Prototype (AEC and undetermined utility)			Organic cooled	50,000		

A. CIVILIAN POWER AND PROPULSION REACTORS— Continued

A.2 Propulsion (Maritime)

Name and/or owner	Nuclear designer	Shipbuilder	Type	Shaft maximum horsepower[1]	Power,[1] kw(t)	Start-up
BEING BUILT						
Nuclear Ship Savannah (AEC and Maritime Administration)	B&W	NYSC	Pressurized water	22,000	69,000	1960
PLANNED						
Tanker (AEC and Maritime Administration)			Light water	30,000	80,000	1964
Maritime Gas Cooled Reactor (AEC and Maritime Administration)	GDC		Gas cooled	22,000	54,000	1964

B. OTHER CIVILIAN REACTORS

B.1 Reactor Experiments, U. S. Locations

Name (all owned by AEC except as noted)	Designation	Location	Principal nuclear contractor	Type	Power[1] Net kw(e)	Power[1] Kw(t)	Start-up	Dismantled
OPERATED, LATER DISMANTLED								
Boiling Reactor Experiment No. 1	BORAX-1	NRTS, Idaho	ANL	Boiling water	No. elec.	1,400	1953	1954
Homogeneous Reactor Experiment No. 1	HRE-1	Oak Ridge, Tenn.	ORNL	Aqueous homogeneous solution (UO_2SO_4)	140	1,000	1952	1954
Los Alamos Power Reactor Experiment No. 1[11]	LAPRE-1	Los Alamos, N. Mex.	LASL	Aqueous homogeneous (phosphoric acid)	No. elec.	2,000	1956	1957
Boiling Reactor Experiments[12]	BORAX-2, 3, 4	NRTS, Idaho	ANL	Boiling water	2,000	15,500	1954	1958
Los Alamos Power Reactor Experiment No. 2	LAPRE-2	Los Alamos, N. Mex.	LASL	Aqueous homogeneous (phosphoric acid)	No. elec.	1,000	1959	1959
OPERABLE								
Experimental Breeder Reactor No. 1[13]	EBR-1	NRTS, Idaho	ANL	Fast breeder	150	1,400	1951	
Experimental Boiling Water Reactor[14]	EBWR	Lemont, Ill.	ANL	Boiling water	4,500	100,000	1956	
Vallecitos Boiling Water Reactor, privately owned (General Electric Company and Pacific Gas and Electric Co.)[15]	VBWR	Pleasanton, Calif.	GE	Boiling water	5,000	30,000	1957	
Sodium Reactor Experiment (AEC and Southern California Edison Co.)	SRE	Santa Susana, Calif.	AI	Sodium Graphite	6,000	20,000	1957	
Organic Moderated Reactor Experiment	OMRE	NRTS, Idaho	AI	Organic moderated	No. elec.	5,000 to 15,000	1957	
Homogeneous Reactor Experiment No. 2	HRE-2	Oak Ridge, Tenn.	ORNL	Aqueous homogeneous	0.3	5,200	1957	

and Southern California Edison Co.)		Calif.					
Organic Moderated Reactor Experiment	OMRE	NRTS, Idaho	AI	Organic moderated	No. elec.	5,000 to 16,000	1957
Homogeneous Reactor Experiment No. 2	HRE-2	Oak Ridge, Tenn.	ORNL	Aqueous homogeneous solution (UO_2SO_4)	0.3	5,200	1957
BEING BUILT							
Experimental Breeder Reactor No. 2	EBR-2	NRTS, Idaho	ANL	Fast breeder	16,500	62,500	1960
Los Alamos Molten Plutonium Reactor Experiment	LAMPRE	Los Alamos, N. Mex.	LASL	Fast molten plutonium fueled, sodium cooled	No elec.	1,000	1960
Experimental Gas Cooled Reactor[16] (AEC and Tennessee Valley Authority)	EGCR	Oak Ridge, Tenn.	KE-ACF	Gas cooled, graphite moderated	22,300	84,300	1962
Boiling Reactor Experiment No. 5	BORAX-5	NRTS, Idaho	ANL	Boiling water	2,000	20,000	1961
PLANNED							
Saxton Nuclear Experimental Reactor Project, privately owned		Saxton, Pa.	West	Pressurized water	5,000		1961
High Temperature Gas Cooled Reactor Experiment[17]	TURRET	Los Alamos, N. Mex.	LASL	Gas cooled	No. elec.	3,000	1962
Experimental Organic Cooled Reactor	EOCR	NRTS, Idaho		Organic	No. elec.	40,000	
Experimental Low Temperature Process Heat Reactor	ELPHR	Point Lown, San Diego, Calif.	SL	Pressurized water	No. elec.	40,000	1962

B.2 General Test

Name and/or owner	Designation*	Location	Principal nuclear contractor	Type	Power,[1] kw(t)	Start-up
OPERABLE						
Materials Testing Reactor (AEC)	MTR	NRTS, Idaho	Fluor	Tank	40,000	1952
Engineering Test Reactor (AEC)	ETR	NRTS, Idaho	KE	Tank	175,000	1957
General Electric Company Materials Testing Reactor	GETR	Pleasanton, Calif.	Owner	Tank	20,000	1958
Westinghouse Testing Reactor	WTR	Waltz Mill, Pa.	Owner	Tank	60,000	1959
BEING BUILT						
National Aeronautics and Space Agency	NASA-TR	Sandusky, Ohio	NASA	Tank	60,000	1960
PLANNED						
Babcock & Wilcox Test Reactor		Lynchburg, Va.	B&W	Tank		

B. OTHER CIVILIAN REACTORS — Continued

B.3 Research and Training

Name and/or owner	Designation	Location	Principal nuclear contractor	Type	Power,[1,18] kw(t)	Start-up	Dismantled
OPERATED, LATER DISMANTLED							
Los Alamos Water Boiler	HYPO	Los Alamos, N. Mex.	LASL	Homogeneous	5.5	1944	1950
Chicago Pile 1, rebuilt as CP-2 (Manhattan Engineering District-AEC)[19]	CP-1	Chicago, Ill.	Met. Lab.	Graphite	0.2	1942	1954
Argonne CP-3 rebuilt as CP-3′ (Manhattan Engineering District-AEC)	CP-3′	Palos Park, Ill.	Met. Lab	Heavy water	300	1944	1955
Los Alamos Fast Reactor (AEC)	Clementine	Los Alamos, N. Mex.	LASL	Fast, plutonium fuel, mercury cooled	25	1946	1953
Atomics International	L-47	Canoga Park, Calif.	AI	Homogeneous	Negligible	1957	1958
OPERABLE							
Oak Ridge Graphite Reactor (AEC)	X-10	Oak Ridge, Tenn.	CL	Graphite	3,800	1943	
Los Alamos Water Boiler (AEC)	SUPO	Los Alamos, N. Mex.	LASL	Homogeneous	25	1950	
Brookhaven Research Reactor (AEC)	BGRR	Upton, N. Y.	HKF	Graphite	20,000	1950	
Low Intensity Test Reactor (AEC)[20]	LITR	Oak Ridge, Tenn.	ORNL	Tank	3,000	1950	
North American Aviation Water Boiler Neutron Source (AEC)[21]	AE-6	Santa Susana, Calif.	AI	Homogeneous	2	1952	
Livermore Water Boiler (AEC)	LIWB(WBNS)	Livermore, Calif.	AI	Homogeneous	0.5	1953	
Livermore Reactor (AEC)		Livermore, Calif.	AI	Solution	0.5	1953	
North Carolina State College (Raleigh Research Reactor)[22]	RRR	Raleigh, N. C.	Owner	Homogeneous	0.5	1957	
Argonne Research Reactor (AEC)[23]	CP-5	Lemont, Ill.	ANL	Heavy water	2,000	1954	
Pennsylvania State University		University Park, Pa.	Owner	Pool	100	1955	
Armour Research Foundation	ARR	Chicago, Ill.	AI	Homogeneous	100	1956	
Battelle Memorial Institute	BRR	West Jefferson, Ohio	AMF	Pool	2,000	1956	
Omega West Reactor (AEC)	OWR	Los Alamos, N. Mex.	LASL	Tank	5,000	1956	
Argonne Naught Power Reactor (AEC)	Argonaut (CP-11)	Lemont, Ill.	ANL	Graphite/water	10	1957	
University of Michigan (Ford Nuclear Reactor)		Ann Arbor, Mich.	B&W	Pool	1,000	1957	
Livermore Pool Type Reactor (AEC)	LPTR	Livermore, Calif.	FW	Tank	1,000	1957	
U. S. Naval Post Graduate School[18]	AGN-201-100	Monterey, Calif.	AGN	Homog. solid	Negligible	1956	
Catholic University of America	AGN-201-101	Washington, D. C.	AGN	Homog. solid	Negligible	1957	
Oklahoma State University of Agri...	AGN-201-102	...	AGN	...	...	...	

Livermore Pool Type Reactor (LPR)	LPR	Livermore, Calif.	PW	Tank	1,000	1957
U. S. Naval Post Graduate School[18]	AGN-201-100	Monterey, Calif.	AGN	Homog. solid	Negligible	1956
Catholic University of America	AGN-201-101	Washington, D. C.	AGN	Homog. solid	Negligible	1957
Oklahoma State University of Agriculture and Applied Science	AGN-201-102	Stillwater, Okla.	AGN	Homog. solid	Negligible	1957
Aerojet-General Nucleonics	AGN-201P-103	San Ramon, Calif.	AGN	Homog. solid	Negligible	1957
University of Akron	AGN-201-104	Akron, Ohio	AGN	Homog. solid	Negligible	1957
National Naval Medical Center (USN)	AGN-201M-105	Bethesda, Md.	AGN	Homog. solid	Negligible	1957
Texas Agricultural and Mechanical College	AGN-201-106	College Station, Tex.	AGN	Homog. solid	Negligible	1957
University of Utah	AGN-201-107	Salt Lake City, Utah	AGN	Homog. solid	Negligible	1957
Aerojet-General Nucleonics	AGN-201-108	Lemont, Ill.	AGN	Homog. solid	Negligible	1957
Colorado State University	AGN-201-109	Ft. Collins, Colo.	AGN	Homog. solid	Negligible	1957
University of California	AGN-201-112	Berkeley, Calif.	AGN	Homog. solid	Negligible	1957
University of Delaware	AGN-201-113	Newark, Del.	AGN	Homog. solid	Negligible	1958
Oregon State College	AGN-201-114	Corvallis, Oreg.	AGN	Homog. solid	Negligible	1958
Curtiss-Wright Corporation		Quehanna, Pa.	Owner	Pool	4,000	1958
General Dynamics Corp.	TRIGA	La Jolla, Calif.	GDC	Homog. solid	30	1958
Neutron Source Reactor (AEC)		Upton, N. Y.	BNL	Tank	1,000	1958
Atomics International	L-77	Canoga Park, Calif.	AI	Homogeneous	Negligible	1958
American Radiator & Standard Sanitary Corp.	UTR-1	Mountain View, Calif.	Owner	Graphite/water	Negligible	1958
Pawling Research Reactor	PRR	Pawling, N. Y.	NDA	Heavy water	Negligible	1958
Massachusetts Institute of Technology	MITR	Cambridge, Mass.	ACF	Heavy water	1,000	1958
Industrial Reactor Laboratories, Inc.		Plainsboro, N. J.	AMF	Pool	5,000	1958
Babcock & Wilcox Lynchburg Pool Reactor	LPR	Lynchburg, Va.	Owner	Pool	10	1958
Rice Institute	AGN-211-101	Houston, Tex.	AGN	Homog. solid, pool	Negligible	1959
University of Oklahoma	AGN-211-102	Norman, Okla.	AGN	Homog. solid, pool	Negligible	1958
University of Arizona	TRIGA	Tuscon, Ariz.	GDC	Heterog. tank	10	1958
Oak Ridge Research Reactor (AEC)	ORR	Oak Ridge, Tenn.	ORNL	Tank	30,000	1958
West Virginia University College of Engineering	AGN-211-103	Morgantown, W. Va.	AGN	Homog. solid, pool	Negligible	1959
Brookhaven Medical Research Reactor	MRR	Upton, N. Y.	Daystrom	Tank	3,000	1959
University of Wyoming	L-77	Laramie, Wyo.	AI	Homogeneous	Negligible	1959
University of Florida		Gainesville, Fla.	GNE	Graphite/water	10	1959
Omaha Veterans Administration Hospital	TRIGA	Omaha, Nebr.	GDC	Heterog. solid, tank	10	1959
Puerto Rico Nuclear Center (AEC)	L-77	Mayagüez, P. R.	AI	Homogeneous	Negligible	1959
Iowa State University	UTR-10	Ames, Iowa	ARSS	Graphite/water	10	1959
Leland Stanford University		Palo Alto, Calif.	GE	Pool	10	1959
Worcester Polytechnic Institute		Worcester, Mass.	GE	Pool	1	1959
Virginia Polytechnic Institute		Blacksburg, Va.	ARSS	Graphite/water	10	1959
BEING BUILT						
University of Virginia		Charlottesville, Va.	Owner-B&W	Pool	1,000	1960

B. OTHER CIVILIAN REACTORS (B.3 Research and Training)— Continued

Name and/or owner	Designation	Location	Principal nuclear contractor	Type	Power,[1,18] kw(t)	Start-up	Dismantled
BEING BUILT (Continued)							
Union Carbide Nuclear Company		Sterling Forest, N. Y.	AMF	Pool	5,000	1961	
Aerojet-General Nucleonics (25 reactors)	AGN-201-(111, 115-117-120, 126-131, 133-140) AGN-201P-(122-125)	San Ramon, Calif.	AGN	Homog. solid	Neglig.	1960	
Aerojet-General Nucleonics (7 reactors)[18]	AGN-211-104-110	San Ramon, Calif.	AGN	Homog. solid, pool	Neglig.	1960	
Cornell University Dual Core Reactor		Ithaca, N. Y.	Vitro	Pool	10	1960	
North Carolina State College		Raleigh, N. C.	Cook	Pool	10	1960	
Puerto Rico Nuclear Center (AEC)		Mayagüez, P. R.	AMF	Pool	1,000	1960	
University of Washington	Educator	Seattle, Wash.	AMF	Graphite/water	10	1960	
University of Buffalo		Buffalo, N. Y.	AMF	Pool	1,000	1960	
Walter Reed Army Institute of Research	L-54	Washington, D. C.	AI	Homogeneous	50	1960	
Nuclear Science Center Reactor, Texas Agricultural and Mechanical College	NSCR	College Station, Texas	Convair	Pool	100	1961	
Brookhaven High Flux Beam Research Reactor		Upton, N. Y.	BNL	Heavy water	20,000	1962	
University of Missouri, School of Mines and Metallurgy		Rolla, Mo.	CW	Pool	10	1960	
State College of Washington		Pullman, Wash.	GE	Pool	100	1960	
University of California at Los Angeles (College of Engineering)	Educator	Los Angeles, Calif.	AMF	Graphite/water	10	1960	
Argonne National Laboratory (AEC)[24]	Juggernaut	Lemont, Ill.	ANL	Graphite/water	250	196.	
PLANNED							
University of Tennessee		Knoxville, Tenn.	NDA	Heavy water	10	1960	
University of Maine	AGN-201-132	Orne, Maine	AGN	Homog. solid	Neglig.	1960	
University of Kansas	Model 4180	Lawrence, Kans.	BAC	Tank	10	1960	
Ohio State University		Columbus, Ohio	Lockheed	Pool	10	1960	
Georgia Institute of Technology		Atlanta, Ga.	GNE	Heavy water	5,000	1961	
University of Illinois	TRIGA-Mk II	Urbana-Champaign, Ill.	GDC	Homog. solid, tank	100	1960	
High Flux Isotope Reactor	HFIR	Oak Ridge, Tenn.	ORNL	Pool flux trap	100,000	1963	
Argonne High Flux Reactor	AHFR	Lemont, Ill.		Flux trap	100,000		
University of Maryland							

High Flux Isotope Reactor	HFIR	Oak Ridge, Tenn.	ORNL	Pool flux trap	100,000	1963
Argonne High Flux Reactor	AHFR	Lemont, Ill.		Flux trap	100,000	
University of Maryland		College Park, Md.	AC	Pool	10	1961
Bethesda Medical Reactor (DOD)		Bethesda, Md.				1961

B.4 Specialized Test

Name (all owned by AEC)	Designation	Location	Principal nuclear contractor	Type	Power,[1] kw(t)	Start-up
OPERABLE						
Bulk Shielding Reactor No. 1[28]	BSR-1	Oak Ridge, Tenn.	ORNL	Pool	1,000	1950
Process Development Pile	PDP	Savannah River, S. C.	du Pont	Heavy water	1	1953
Thermal Test Reactor	SP	Savannah River, S. C.	du Pont	Graphite	1 to 10	1953
Special Power Excursion Reactor Test No. 1[29]	SPERT-1	NRTS, Idaho	PPC	Open tank		1955
Kinetic Experiment on Water Boilers	KEWB	Santa Susana, Calif.	AI	Homogeneous	50	1956
General Electric Nuclear Test Reactor	NTR	Pleasanton, Calif.	GE	Light water	30	1957
Special Power Excursion Reactor Test No. 3[30]	SPERT-3	NRTS, Idaho	PPC	Pressurized water	60,000	1958
Transient Test Reactor Facility	TREAT	NRTS, Idaho	ANL	Graphite	100	1959
Fast Source Reactor	FSR	NRTS, Idaho	ANL	Fast	1	1959
BEING BUILT						
Special Power Excursion Reactor Test No. 2[29]	SPERT-2	NRTS, Idaho	PPC	Pressurized heavy water		1960
Plutonium Recycle Test Reactor	PRTR	Hanford, Wash.	GE	Heavy water moderated and cooled pressure tube	70,000	1960
Heavy Water Components Test Reactor	HWCTR	Savannah River, S. C. (TC-1 Area)	du Pont	Pressurized heavy water	60,000	1961
PLANNED						
Biological Research Reactor	JANUS	Lemont, Ill.	ANL	Tank	200	1961
Special Power Excursion Reactor Test No. 4[29]	SPERT-4	NRTS, Idaho	PPC	Pool		

C. MILITARY PROPULSION, POWER, AND TEST REACTORS

C.1 Naval Propulsion

Name (all owned by U. S. Navy)	Designation	Nuclear designer	Shipbuilder	Type[22]	Start-up	Dismantled
OPERATED, LATER DISMANTLED						
Seawolf S2G Sodium Reactor		GE		Sodium	1956	1959
OPERABLE						
USS Nautilus	SSN571	West	Elec. Boat	S2W	1955	
USS Skate	SSN578	West	Elec. Boat	S3W	1957	
USS Swordfish	SSN579	West	Portsmouth	S4W	1958	
USS Sargo	SSN583	West	Mare Island	S3W	1958	
USS Skipjack	SSN585	West	Elec. Boat	S5W	1958	
USS Seadragon	SSN584	West	Portsmouth	S4W	1959	
USS Triton (2 reactors)	SS(R) N586	GE	Elec. Boat	S4G	1959	
USS Halibut	SS(G) N587	West	Mare Island	S3W	1959	
USS George Washington	SSB(N)598	West	Elec. Boat	S5W	1959	
BEING BUILT						
Submarine Scamp	SSN588	West	Mare Island	S5W		
Submarine Scorpion	SSN589	West	Elec. Boat	S5W		
Submarine Sculpin	SSN590	West	Ingalls	S5W		
Submarine Shark	SSN591	West	Newport News	S5W		
Submarine Snook	SSN592	West	Ingalls	S5W		
Submarine Thresher	SSN593	West	Portsmouth	S5W		
Submarine Permit	SSN594	West	Mare Island	S5W		
Submarine Plunger	SSN595	West	Mare Island	S5W		
Submarine Pollack	SSN596	West	Ingalls	S5W		
Submarine Tullibee	SSN597	CE	Elec. Boat	S2C		
Submarine Patrick Henry	SSB(N)599	West	Elec. Boat	S5W		
Submarine Theodore Roosevelt	SSB(N)600	West	Mare Island	S5W		
Submarine Robert E. Lee	SSB(N)601	West	Newport News	S5W		
Submarine Abraham Lincoln	SSB(N)602	West	Portsmouth	S5W		
Submarine Barb	SSN603	West	NYSC	S5W		
Submarine Haddo	SSN604	West	NYSC	S5W		
Submarine Jack	SSN605	West	Portsmouth	S5W		
Submarine Tinosa	SSN606	West	Portsmouth	S5W		
Submarine Dace	SSN607	West	Ingalls	S5W		
Submarine Ethan Allen	SSB(N)608	West	Elec. Boat	S5W		
Submarine Sam Houston	SSB(N)609	West	Newport News	S5W		
Submarine Thomas A. Edison	SSB(N)610	West	Elec. Boat	S5W		
Submarine John Marshall	SSB(N)611	West	Newport News	S5W		
Guided Missile Cruiser Long Beach (2 reactors)	CG(N)9	West	Bethlehem	C1W		
Aircraft Carrier Enterprise (8 reactors)	CVA(N)65	West	Newport News	A2W		
Guided Missile Destroyer	DLG(N)25	GE	Bethlehem	D2G		

Aircraft Carrier Enterprise (8 reactors)	CVA(N)65	West	Newport News	A2W
Guided Missile Destroyer Bainbridge (2 reactors)	DLG(N)25	GE	Bethlehem	D2G
S5W for HMS Dreadnaught		West		S5W
UNDER CONVERSION				
USS Seawolf	SSN575	West	Elec. Boat	S2Wa
AUTHORIZED				
Submarine	SSN612	West		S5W
Submarine	SSN613	West		S5W
Submarine	SSN614	West		S5W
Submarine	SSN			S5W

C.2 Prototypes, Experiments, and Field Plants

Name (all owned by AEC except as noted)	Designation	Location	Principal nuclear contractor	Type	Power,[1] net kw(e)	Start-up	Dismantled
OPERATED, LATER DISMANTLED							
Heat Transfer Reactor Experiment No. 1[28]	HTRE-1	NRTS, Idaho	GE-ANPD	Air cooled		1956	1957
Aircraft Reactor Experiment	ARE	Oak Ridge, Tenn.	ORNL	Molten salt		1954	1954
Submarine Intermediate Reactor Mark A	S1G	West Milton, N. Y.	GE	Sodium		1955	1957
Small Scale Nuclear Rocket Propulsion Experiment (Project Rover)	KIWI-A	NTS, Nev.	LASL	Open cycle gas		1959	1959
OPERABLE							
S1W Reactor Facility	S1W	NRTS, Idaho	West	Pressurized water		1953	
Stationary Medium Power Plant No. 1 (Formerly APPR-1)	SM-1	Ft. Belvoir, Va.	Alco	Pressurized water	1,855	1957	
Large Ship Reactor Prototype (2 reactors)	A1W	NRTS, Idaho	West	Pressurized water		1958	
Submarine Advanced Reactor Prototype	S3G	West Milton, N. Y.	GE	Pressurized water		1958	
Stationary Low Power Plant No. 1 (Formerly ALPR)[29]	SL-1	NRTS, Idaho	ANL	Boiling water	200	1958	
Heat Transfer Reactor Experiment No. 2	HTRE-2	NRTS, Idaho	ANPD	Air cooled			
Heat Transfer Reactor Experiment No. 3	HTRE-3	NRTS, Idaho	ANPD	Air cooled			
Small Submarine Reactor Prototype	S1C	Windsor, Conn.	CE	Pressurized water		1959	
SNAP Experimental Reactor Test	SER	Santa Susana, Calif.	AI		50	1959	

C. MILITARY PROPULSION, POWER, AND TEST REACTORS (C.2 Prototypes, Experiments, and Field Plants) — Continued

Name (all owned by AEC except as noted)	Designation	Location	Principal nuclear contractor	Type	Power,[1] net kw(e)	Start-up	Dismantled
BEING BUILT							
Gas Cooled Reactor Experiment	GCRE-1	NRTS, Idaho	AG	Gas cooled	No. elec.	1960	
Destroyer Reactor Prototype	D1G	West Milton, N. Y.	GE	Pressurized water			
Stationary Medium Power Plant No. 1A (USA)[30]	SM-1A	Fort Greely, Alaska	Alco	Pressurized water	1,700	1960	
Portable Medium Power Plant No. 1 (USAF-AEC)[31]	PM-1	Sundance, Wyo.	Martin	Pressurized water	1,000	1961	
Portable Medium Power Plant No. 2A (USA)[32]	PM-2A	Camp Century, Greenland	Alco	Pressurized water	1,500	1960	
Mobile Low Power Plant No. 1	ML-1	NRTS, Idaho	AG	Gas cooled	400	1961	
Intermediate Scale Nuclear Rocket Propulsion Experiment (Project ROVER)	KIWI-A'	NTS, Nev.	LASL				
Intermediate Scale Nuclear Rocket Propulsion Experiment (Project ROVER)	KIWI-A3	NTS, Nev.	LASL				
Experimental Reactor	PWAC-II	Middletown, Conn.	P&W				
Experimental Power Reactor Test (Project PLUTO)	Tory-II	NTS, Nev.	UCLRL				
PLANNED							
Natural Circulation Test Plant	NCR	NRTS, Idaho	GE	Pressurized water		1962	
Intermediate Scale Nuclear Rocket Propulsion Experiment (Project ROVER)	KIWI-B1	NTS, Nev.	LASL				
Intermediate Scale Nuclear Rocket Propulsion Experiment (Project ROVER)	KIWI-B2	NTS, Nev.	LASL				
Intermediate Scale Nuclear Rocket Propulsion Experiment (Project ROVER)	KIWI-C	NTS, Nev.	LASL				
SNAP Developmental System	SDS	Santa Susana, Calif.	AI				
SNAP Prototype System	SPS	Santa Susana, Calif.	AI				
SNAP Flight System	SFS	Santa Susana, Calif.	AI				
Advanced Core Test	ACT	NRTS, Idaho	ANPD				

SNAP Flight System	SFS	Santa Susana, Calif.	AI	
Advanced Core Test	ACT	NRTS, Idaho	ANPD	

C.3 Research and Test

Name and/or owner	Designation	Location	Principal nuclear contractor	Type	Power,[1] kw(t)	Start-up	Dismantled
OPERATED, LATER DISMANTLED							
Tower Shielding Reactor No. 1 (AEC)	TSR-1	Oak Ridge, Tenn.	ORNL	Tank	500	1954	1958
OPERABLE							
Thermal Test Reactor No. 1 (AEC)	TTR-1	Schenectady, N. Y.	GE	Graphite	10	1951	
Ground Test Reactor (USAF)	GTR	Ft. Worth, Tex.	Convair	Pool	500	1953	
Aircraft Shield Test Reactor (USAF)	ASTR	Ft. Worth, Tex.	Convair	Light water	1,000	1954	
Naval Research Reactor (USN)	NRR	Washington, D. C.	NRL	Pool	100	1956	
Radiation Effects Reactor (USAF)	RER	Dawsonville, Ga.	Lockheed	Tank	10,000	1958	
Shield Test Pool Facility	Susie	NRTS, Idaho	ANPD	Pool	10 to 100	1959	
BEING BUILT							
Tower Shielding Reactor No. 2 (AEC)	TSR-2	Oak Ridge, Tenn.	ORNL	Light water	5,000	1960	
Nuclear Engineering Test Reactor (USAF)[33]	NETR	Dayton, Ohio	Maxon-AC	Pool	10,000		
Ordnance Materials Research Office (USA)		Watertown, Mass.	Owner	Pool	1,000	1960	
Sandia Engineering Reactor Facility (AEC)	SERF	Sandia Base, N. Mex.	Sandia	Tank	5,000	1960	
PLANNED							
Nuclear Test Plant (AEC)	NTP	NRTS, Idaho	CE	Pressurized water	60,000	1961	
Shield Test Air Facility (AEC)	STAR	NRTS, Idaho	ANPD				
Sandia Pulsed Reactor Facility (AEC)	SPRF	Sandia Base, N. Mex.	Sandia	Prompt burst		1961	

D. PRODUCTION REACTORS

D.1 Materials Production

Designation	Nuclear designer	Type	Location
OPERABLE			
B Reactor	du Pont	Graphite	Hanford, Wash.
D Reactor	du Pont	Graphite	Hanford, Wash.
F Reactor	du Pont	Graphite	Hanford, Wash.
C Reactor	GE	Graphite	Hanford, Wash.
DR Reactor	GE	Graphite	Hanford, Wash.
H Reactor	GE	Graphite	Hanford, Wash.
KE Reactor	GE	Graphite	Hanford, Wash.
KW Reactor	GE	Graphite	Hanford, Wash.
R Reactor	du Pont	Heavy water	Savannah River, S. C.
P Reactor	du Pont	Heavy water	Savannah River, S. C.
K Reactor	du Pont	Heavy water	Savannah River, S. C.
L Reactor	du Pont	Heavy water	Savannah River, S. C.
C Reactor	du Pont	Heavy water	Savannah River, S. C.
BEING BUILT			
New Production Reactor[34]	GE	Graphite	Hanford, Wash.

D.2 Test

Name (all owned by AEC)	Designation	Location	Nuclear designer	Type	Power,[1] kw(t)	Start-up
OPERABLE						
Hanford 305 Test Reactor	HEW-305	Hanford, Wash.	du Pont	Graphite	0.03	1944
Savannah River Test Pile 305	SR-305	Savannah River, S. C.	du Pont	Graphite	1	1953
Physical Constants Test Reactor	PCTR	Hanford, Wash.	GE	Graphite	0.1	1955
Thermal Test Reactor No. 2	TTR-2	Hanford, Wash.	GE	Graphite	0.1	1955

E. REACTORS FOR EXPORT

Savannah River Test Pile 305	SR-305	Savannah River, S. C.	GE	Graphite	0.1	1955
Physical Constants Test Reactor	PCTR	Hanford, Wash.	GE	Graphite	0.1	1955
Thermal Test Reactor No. 2	TTR-2	Hanford, Wash.				

E. REACTORS FOR EXPORT

E.1 Stationary Power

Name and/or owner	Location	Principal nuclear contractor	Type	Power[1] Net kw(e)	Power[1] Kw(t)	Start-up
BEING BUILT						
Belgium (Center for the Study of Nuclear Energy, CEN)	Mol	West	Pressurized water	11,500	43,000	1960
Germany (Rhine–Westphalia Power Co., RWE)	Kahl-am-Main	GE	Boiling water	15,000	62,000	1960
Italy (Project Enrico Fermi of SELNI, Edisonvolta)[35]	Milan	West	Pressurized water	160,000	615,000	1963
PLANNED						
Cuba, Government of (National Bank for Social and Economic Development, BANDES)[36]	Santa Lucia	AMF	Boiling water	20,500	75,000	1961
Italy (Project ENSI of SENN)	Punta Fiume	GE	Boiling water	150,000	508,000	1962
Japan, Government of (JAERI)	Tokai-Mura	GE	Boiling water	10,000	40,000	1962

E.2 Research, Training, and Testing

Owner	Location	Principal nuclear contractor	Type	Power,[1,18] kw(t)	Start-up
OPERABLE					
Belgium Congo, Government of (University of Lovanium)[37]	Leopoldville	GDC	TRIGA	10	1958
Brazil, Government of (University of São Paulo)	São Paulo	B&W	Pool	5,000	1957
Canada (McMaster University)	Hamilton, Ont.	AMF	Pool	1,000	1959
Denmark, Government of (Atomic Energy Commission)	Risö	AI	L-54	Neglig.	1957
Denmark, Government of (Atomic Energy Commission)	Risö	FW	Tank	5,000	1959
Germany (Interatom, Inc.)[38]	Duisberg	AI	L-77	Neglig.	1958
Germany, Federal Republic of (Hoechst Dyeworks, Inc.)	Frankfurt	AI	L-54	50	1958
Germany, Federal Republic of (Society for the Utilization of Nuclear Energy in Shipbuilding and Navigation, Inc.)	Geesthacht	B&W	Pool	5,000	1958
Germany, Federal Republic of (Technical University of Munich)	Munich	AMF	Pool	1,000	1957
India (First World Agricultural Fair, U. S. Exhibit)	New Delhi	GDC	TRIGA-Mk II	100	1959
Italy (Milan Technical University)	Milan	AI	L-54	50	1959
Italy (SORIN Nuclear Center)	Chivasso	AMF	Pool	1,000	1959
Italy (University of Palermo)	Palermo	AGN	201-110	Neglig.	1958

E. REACTORS FOR EXPORT (E.2 Research, Training, and Testing)—Continued

Owner	Location	Principal nuclear contractor	Type	Power,[1,18] kw(t)	Start-up
OPERABLE (Continued)					
Italy, Government of (National Committee for Nuclear Research)	Ispra	AC	Heavy water, tank	5,000	1959
Japan, Government of (Atomic Energy Research Institute)	Tokai-Mura	AI	L-54	50	1957
Netherlands, Government of (Delft Technical University)[39]	Delft	AMF	Pool	100	1957
Spain, Government of (Nuclear Energy Board)	Madrid	GE	Pool	3,000	1958
Switzerland (University of Basel)[40]	Basel	AGN	211-100	Neglig.	1958
Switzerland (University of Geneva)[41]	Geneva	AGN	201-111	Neglig.	1958
Switzerland, Government of (Reactor, Inc.)[42]	Wuerenlingen	ORNL	Pool	1,000	1955
West Berlin, City of (Hahn-Meitner Institute for Nuclear Research)	West Berlin	AI	L-54	50	1958
BEING BUILT					
Austria, Government of (Ministry of Education)	Vienna	GDC	TRIGA-Mk II	100	1960
Austria, Government of (Seibersdorf Research Center)	Seibersdorf	AMF	Pool	5,000	1960
Brazil (University of Minas Gerais)	Belo Horizonte	GDC	TRIGA	30	
China, Republic of (National Tsing-Hau University)	Hsinchu	GE	Pool	1,000	1960
Greece, Government of (Atomic Energy Commission)	Athens	AMF	Pool	1,000	1960
Iran, Government of (University of Tehran)	Tehran	AMF	Pool	5,000	1961
Israel, Government of (Atomic Energy Commission)	Tel-Aviv	AMF	Pool	1,000	1960
Italy (Naval Academy and University of Pisa C.A.M.E.N.)	Livorno	B&W	Pool	5,000	1961
Italy, Government of (National Committee for Nuclear Research)	Rome	GDC	TRIGA-Mk II	100	1960
Japan (Kinki University)	Osaka	ARSS		Neglig.	1960
Japan, Government of (Atomic Energy Research Institute)	Tokai-Mura	AMF	Heavy water	10,000	1960
Netherlands, Government of (Reactor Center)	Petten	AC	Tank (MTR)	20,000	1961
Phillipines, Government of (National Science Development Board)	Quezon City	GE	Pool	1,000	1961
Portugal, Government of (Nuclear Energy Board)	Lisbon	AMF	Pool	1,000	1960
Sweden, Government of (Atomic Energy Company)	Studsvik	AC	Tank (MTR)	30,000	1960
Thailand (Chulalongkorn University)	Bangkok	CW	Pool	1,000	1961
Turkey, Government of (Atomic Energy Commission)[43]	Istanbul	AMF	Pool	1,000	1960
Venezuela, Government of (Institute of Neurology and Brain Research)	Caracas	GE	Pool	3,000	1960
Vietnam, Government of[43]	Dalat	GDC	TRIGA-Mk II	100	1961
PLANNED					
Finland, Government of (Institute of Technology)	Helsinki	GDC	TRIGA-Mk II	100	
Germany (University of Mainz)	Mainz	GDC	TRIGA-Mk II	100	
Japan (Musashi Institute of Technology)	Kawasaki City	GDC	TRIGA-Mk II	100	
Japan (Rikkyo University)	Yokosuka City	GDC	TRIGA-Mk II	100	1961
Japan (St. Paula University)	Tokyo	GDC	TRIGA-Mk II	100	
Korea, Government of (Atomic Energy Commission)	Seoul	GDC	TRIGA-Mk II	100	1960
Pakistan, Government of (Atomic Energy Commission)	Taxila	AMF	Pool	1,000	

E.3 Critical Assembly Facilities

Japan (Rikkyo University)	Tokyo	GDC	TRIGA-Mk II	100	
Japan (St. Pauls University)	Seoul	GDC	TRIGA-Mk II	100	1960
Korea, Government of (Atomic Energy Commission)	Taxila	AMF	Pool	1,000	
Pakistan, Government of (Atomic Energy Commission)					

E.3 Critical Assembly Facilities

Name and/or owner	Location	Subject of experiment or study	Designation	Start-up
PLANNED				
Japan, Government of (JAERI)	Tokai-Mura			

F. CRITICAL ASSEMBLY FACILITIES

F.1 Identification of Facilities

Abbreviation	Name and location of facility	Operator	No. of cells	No. of control panels
AC	Allis-Chalmers Critical Experiment Facility, Greendale, Wis.	Owner	1	1
AI	Atomics International Critical Experiment Laboratory (AEC), Santa Susana, Calif.	AI	3	3
Alco	Alco Products, Inc., Schenectady, N. Y.	Owner	1	1
ANL	Argonne National Laboratory (AEC), Lemont, Ill.	ANL	3	3
ANL-ID	Argonne National Laboratory, Idaho Division (AEC), NRTS, Idaho	ANL	1	1
ARMF	Advanced Reactivity Measurement Facility (AEC), NRTS, Idaho	PPC	1	1
Bettis	Bettis Plant (AEC), Pittsburgh, Pa.	West	8	8
BMI	Battelle Memorial Institute, West Jefferson, Ohio	Owner	1	1
BNL	Brookhaven National Laboratory (AEC), Upton, N. Y.	BNL	2	2
B&W	The Babcock & Wilcox Co., Lynchburg, Va.	Owner	3	2
CANEL	Connecticut Aircraft Nuclear Engine Laboratory (AEC), Middletown, Conn.	P&W	2	2
CE	Nuclear Engine Laboratory of Combustion Engineering, Inc., Windsor, Conn.	Owner	3	2
ETRC	Engineering Test Reactor Critical Facility (AEC), NRTS, Idaho	PPC	1	1
GDC	General Dynamics Corp., San Diego, Calif.	Owner	2	2
GE	General Electric Company, Vallecitos Laboratory Experimental Physics Facility, Pleasanton, Calif.	Owner	1	1
GEANP	Evendale Critical Experiment Facility (AEC), Evendale, Ohio	GE	2	2
KAPL	Knolls Atomic Power Laboratory (AEC), Schenectady, N. Y.	GE	7	7
LAC	Lockheed Aircraft Corp., Dawsonville, Ga. (USAF)	Owner	1	1
LASL	Los Alamos Scientific Laboratory, Los Alamos, N. Mex.	LASL		
Livermore	University of California Lawrence Radiation Laboratory Critical Assembly Area (AEC), SAGA Building, Livermore, Calif.	UCLRL		
LPTF	Low Power Test Facility (AEC), NRTS, Idaho	GE	2	2
Martin	Martin Co., Middle River, Md.	Owner	2	2
NASA	Lewis Flight Propulsion Laboratory, Sandusky, Ohio	Owner	1	1
NDA	Nuclear Development Corporation of America, Pawling, N. Y.	Owner	1	1

F. CRITICAL ASSEMBLY FACILITIES (F.1 Identification of Facilities)—Continued

Abbreviation	Name and location of facility	Operator	No. of cells	No. of control panels
ORNL-CF	Oak Ridge National Laboratory Critical Facility (AEC), Oak Ridge, Tenn.	ORNL	3	5
ORNL-PCA	Pool Critical Assembly, BSF Pool (AEC), Oak Ridge, Tenn.	ORNL	1	1
RMF	Reactivity Measurement Facility, MTR Canal (AEC), NRTS, Idaho	PPC	1	1
UCLRL-NTS	University of California Lawrence Radiation Laboratory (AEC), NTS, Nev.	UCLRL		
West	Westinghouse Reactor Evaluation Center Critical Experiment Station (CES) and Yankee Critical Facility (YCF), Waltz Mill, Pa.	Owner	2	2

F.2 Identification of Experiments and Studies

Facility and location within facility	Subject of experiment or study	Designation	Start-up	Dismantled
OPERATED, LATER DISMANTLED				
LASL	Los Alamos Water Boiler Critical Experiment	LOPO-CX	1943	1944
LASL, Kiva I	Studies of core configuration in thick natural U or Ni reflectors	Topsy (Popsy) (Scripto)	1948	1957
LASL, Kiva I and II	Bare metal prompt burst neutronics studies	Godiva I	1951	1957
LASL, Kiva I	Flooding tests	Aquarium		
LASL, Kiva I	Studies of D_2O moderated and reflected spheres	Pot	1952	1953
LASL, Kiva I	Studies of bare D_2O moderated cylinders	Can	1953	1955
LASL, Kiva II	Solid-fuel mockup of LAMPRE	LCX		1959
LASL, Kiva I	Critical Experiments for Kiwi-A (ROVER)	ZEPO	1958	1959
LASL	Classified			
LASL	Classified			
Livermore, SAGA Building	Nuclear data	Puppy I and II, Snoopy	1956	1957
ORNL, Building 205	Nuclear safety and reactor design studies	X-10-200	1945	1948
ORNL, Building K-25	Nuclear physics and nuclear safety with uranium solutions	K-25	1946	1950
ORNL, Y-12 Area	Test reactor assembly No. 1	TRA-1	1954	1954
Bettis	Spare Plate Critical Assembly	SPCA	1952	1955
Bettis	Danger Coefficient Test Facility	DCTF	1953	1957
Bettis	Production Test Facility	PTF	1956	
Bettis	S5W core design	S5W-FA	1956	1958
Bettis	Reactivity physics measurements	RPF	1958	1959

OPERABLE

Bettis	S5W core design	SW-FA	1958	1959
Bettis	Reactivity physics measurements	RPF	1958	1959

OPERABLE

AI, OMCA	Nuclear properties of organic moderated systems		1959
AI, SCGA	Nuclear properties of sodium graphite systems		1959
Alco	APPR-1A core design	APPR-s	1956
ANL-ID	Fast critical mass determinations	ZPR-3	1955
ANL, Building 316, Cell A[44]	Nuclear constants with fast exponential source	ZPR-4	1957
ANL, Building 316, Cell B	Interactions between two basic systems	ZPR-5	1956
ANL, Building 316, Cell C	Boiling water concept nuclear design information	ZPR-7	1957
Bettis	Two region physics	TRX	1953
Bettis	Surface ship physics[45]	SS-CFA	1956
Bettis	Surface ship physics[45]	SS-CFB	1957
Bettis	PWR core 1 physics	PWR-FA-1	1954
Bettis	PWR core 2 physics	PWR-FA-2	1957
Bettis	S5W core 4 physics[45]	SUB-FA and FC	1954
B&W, Cell 1	Consolidated Edison reactor		1957
B&W, Cell 2[46]	Critical experiments with Nuclear Ship Savannah Production Fuel		1958
B&W, Cell 3[46]	LMFRE physics data		1958
BMI, Cell 1[47]	Reflector control critical	BMI-CX	1957
BNL, Building T-526	Exponential and critical assembly		1956
CE, Building 1, Cell 1, Pot 1[48]	S1C physics and mock-up	S1C-FC	1956
CE, Building 2, Cell 1, Pot 1	Vacant		
CE, Building 2, Cell 2, Pot 1[48]	S1C advanced mock-up	S1C-AC	1956
CANEL, Physics Building, Cell 1	Sodium–stainless-steel criticals		1958
CANEL, Physics Building, Cell 2	Aircraft propulsion		1959
ETRC, ETR-MTR Area	ETR physics, core loading and core design		1957
GDC, Cell 1	Zirconium–uranium hydride fuel for TRIGA	CIRGA	1957
GE, Cell 1	Commonwealth Edison reactor		1957
GEANP-1[49]	Criticals for direct-cycle reactors	SMR	1955
GEANP-2	Criticals for direct-cycle reactors	TSM-CERA	1956
KAPL	Physical data[50]	PPA	1948
KAPL	Reactor physics studies with plastic moderator and mock-up[51]	PMA	1954
KAPL	Submarine advanced reactor mock-up	ATR	1954
KAPL	SAR physics and mock-up	FPR	1956
KAPL	D1G cold-water mock-up	CWA	1958
KAPL	SAR high-temperature and -pressure physics and mock-up	PTR	1958
KAPL	RER core configurations	CERF	1958
LAC	Enriched metal in 3-in.-thick uranium reflector	Little Eva	1951
LASL	Plated bare plutonium (to be replaced by U^{233}) sphere studies	Jezebel	1954
LASL, Kiva I	Cold criticals for ROVER reactors	Honeycomb	
LASL, Kiva I	Cold criticals for ROVER reactors	Aunt Polly	
LASL	Jacketed enriched-core lateral and base reflector of water studies, used as neutron sources for exponential column	Hydro	1956
LASL, outside Kiva II	Super prompt critical bursts with plated bare enriched core	Godiva II	1957
LASL, Kiva II	Spherical metal cores in thick metal reflector	Flattop	1957
LASL, Kiva II	Critical configuration safety tests	Comet	
LASL, Kiva I	Critical configuration safety tests	Planet	
LASL, Kiva II	Critical configuration safety tests	Planet II	
LASL			

F. CRITICAL ASSEMBLY FACILITIES (F.2 Identification of Experiments and Studies)—Continued

Facility and location within facility	Subject of experiment or study	Designation	Start-up	Dismantled
OPERABLE (Continued)				
LASL, Kiva II	Physics measurements of thin enriched-uranium foils in thick D_2O reflector	Cavity Reactor		
LASL	Classified			
Livermore, SAGA Building	Critical measurements with different geometries		1953	
Livermore, SAGA Building	Project Pluto cold critical experiments		1957	
NAA-AI	Criticals for SNAP reactors	Powder Compact		
NTS, Nevada	Hot criticals for Tory II (Project Pluto)	Hot Box		
LPTF, Cell 1	Hot critical experiments	HOTCE		
LPTF, Cell 2	Critical experiment tank for advanced-reactor-design testing	CET		
Martin, Cell 1	Martin power reactor experiments		1957	
Martin, Cell 2	Engineer Research and Development Laboratory experiments		1958	
NASA, Materials and Stresses Building	NASA Test Reactor critical experiments		1959	
RMF, MTR canal	Reactor physics constants and reactivity changes caused by test reactor irradiation		1954	
West, YCF	Loose lattice critical experiments			
West, CES	Reactor-fuel-measurement facility design		1958	
NDA, Cell 1[61]	Development of research reactor	NDA-CX	1957	
ORNL-CF, Building 9213, Cell E	Uranium-paraffin experiments related to physics and safety of homogeneous reactors	CA-28	1950	
ORNL-CF, Building 9213, Cell W	Reactor physics and nuclear safety studies with homogeneous uranium solutions; lattices slightly enriched uranium in water; TSR-2 tests; investigations of neutron absorbers as poisons in chemical processing equipment		1950	
ORNL-CF, Building 9213, Cell S	Comparison of nuclear properties of U^{239} and U^{233}			
ORNL-PCA, Building 3010	Physics research on reactivity effects	PCA	1958	
AC	Northern States Power Reactor critical experiment	CRBR-CX	1959	
BEING BUILT				
Bettis	High-temperature physics and mock-up	HTTF	1960	
AI, ECEL	Nuclear properties of experimental reactor systems		1960	
ANL, Building 315	Basic fast reactor theoretical studies	ZPR-6	1960	
ANL, Building 315	Coupled fast core-thermal breeder blanket	ZPR-9	1960	
BNL, Building 526	Graphite-bismuth-uranium system physics data		1960	
LASL	Kiva heated critical assembly			
West, LRX	Physical constants of critical assemblies moderated with D_2O and containing as fuel slightly enriched uranium in the form of UO_2	CVTR-CRX	1960	
GDC	HTGR critical experiment	HTGR-CV	1960	
PLANNED				
ARMF, ETR-MTR Area	Reactor physics constants and reactivity changes caused by test reactor irradiation		1960	
Livermore, SAGA Building	Tory II critical experiments		1960	
KAPL	NCR critical experiments		1960	

FOOTNOTES

	reactor irradiation	
Livermore, SAGA Building	Tory II critical experiments	1959
KAPL	NCR critical experiments	1960

FOOTNOTES

1. The capacity figures for power reactors are based on the best available information. In some cases future modification in plans may cause changes.
2. The Shippingport station is provided with a turbogenerator rated at 100,000 kw(e).
3. Of the total net output shown for the Consolidated Edison plant, 151,000 kw will be nuclear and 104,000 kw will be oil-fired superheat.
4. The Enrico Fermi plant is to be provided with a turbogenerator rated at 150,000 kw(e) and may reach this gross output with later cores.
5. The contract was awarded by the AEC under the Power Demonstration Reactor Program.
6. The net electrical kilowatt output for the Yankee's second core is expected to be 134,000.
7. The net output of the Elk River plant includes about 15,000 kw conventional superheat.
8. The capacity of the Northern States plant includes about 17,000 kw(e) nuclear superheat.
9. Approved as basis for the AEC contract negotiations under the Power Demonstration Reactor Program.
10. The net electric output with an all graphite core is expected to be 40,000 kw.
11. LAPRE-1 was designed as a small reactor experiment that was to produce 2000 kw of heat power. It operated only very briefly and never succeeded in reaching full power.
12. Originally built and operated in 1954 as the Boiling Reactor Experiment No. 2 (BORAX-2). With the addition of a turbogenerator, it operated during 1955 as BORAX-3. BORAX-4 was a further modification which operated from December 1956 until June 1958 when the experiment was shut down indefinitely.
13. Gross electrical kilowatt output is shown for EBR-1 in the tabulation. In a trial run on December 21 and 22, 1951, EBR-1 generated the world's first electric power from nuclear energy. Criticality with the third core was achieved in November 1957.
14. EBWR was successfully operated at a power level of 62,000 kw of heat in experiments on March 20, 1958. It is now being converted to a 100,000-kw thermal plant, but its electrical output is limited by turbogenerator capacity. Plant modification is scheduled for completion by June 1960.
15. In January 1958, VBWR, a privately owned facility, operated at a power level of 30,000 kw of heat. Its electrical output is limited by turbogenerator capacity.
16. The power output of EGCR will depend on the operation of the eight experimental loops to be provided in the core.
17. The purpose of this reactor is to investigate problems associated with high-temperature process heat reactors.
18. Reactors whose thermal power output is less than 50 watts are shown as having negligible power output. The thermal power of these reactors is as follows: AGN 201's, 100 mw; AGN 201M's, 5 watts; AGN 201P's, 20 watts; AGN 211's, 15 watts; AI's L-47 and L-77, 10 watts; ARSS' UTR-1, 1 watt; and NDA's PRR, 5 watts.
19. In 1943, the Manhattan Engineering District disassembled Chicago Pile 1 and rebuilt it at Palos Park, Ill., as Chicago Pile 2. CP-2 had a thermal power level of 10 kw.
20. LITR began as a mechanical model of the MTR. After MTR engineering aspects were proved, small amounts of nuclear fuel, control devices, shielding, and instruments were added; and the reactor, called MTR critical experiment, went critical for the first time in the spring of 1950. Research facilities were added, and power was increased to the present level in the fall of 1951.
21. AE-6 (also designated WBNS) was built and first operated at Downey, Calif. It was moved to Santa Susana in 1957.
22. The original 10-kw research reactor at Raleigh, N. C., was started up in 1953 and was dismantled in 1955. The reactor was reactivated with a 500-watt core in March 1957. Early in 1959, the reactor was moved to a new location in the Nuclear Science Laboratory and a new 10-kw heterogeneous-core Argonaut type reactor was built in the original RRR shield vacated by the homogeneous core.
23. CP-5 is undergoing modifications to permit operation at 10,000 kw(t).
24. After the assembly and operation of this reactor in the Government exhibit at Geneva in September 1958, it was dismantled and returned to ANL where it is being rebuilt as a 100-kw(t) Juggernaut.
25. In 1959, BSR-1 began operating with a second core in which the fuel was clad in stainless steel rather than aluminum.
26. Operated for reactor transient experiments only. The thermal power level shown for SPERT-3 is the maximum heat-removal rate for a one-half hour period and is not a sustaining operating level.
27. All reactors in the naval propulsion program are of the pressurized-water type except the sodium-cooled system formerly installed in the Seawolf. Symbols in the type column indicate (1) the ship type for which the reactor is designed, (2) the sequence number of the plant design by the prime contractor for each ship type, and (3) the designator letter for the name of the contractor responsible for the design of the reactor plant. When appearing as the first letter of the symbol, S indicates submarine; D, destroyer; C, cruiser; and A, large surface ship. The prime-contractor designation letters are W for Westinghouse, G for General Electric, and C for Combustion Engineering.
28. This reactor was partially dismantled in 1957. It could be made operable again if desired, but there are no present plans to do so.

29. SL-1 can produce 1.3 million Btu per hour of space heat, although this output is now being dissipated through a heat dump. The plant is now being operated by Combustion Engineering.
30. SM-1A, formerly known as APPR-1A, will produce 38 million Btu per hour of steam for space heating in addition to electricity.
31. PM-1, formerly known as APPR-2, will produce 7 million Btu per hour of steam for space heating in addition to electricity.
32. PM-2A is being built for the U. S. Army Corps of Engineers. The plant will produce 1000 lb of steam per hour (1 million Btu) and 1500 net kw(e).
33. NETR was originally scheduled for operation in 1960. The present schedule is indefinite.
34. The design of this reactor incorporates features making possible conversion to permit power take-off should this be desirable at a later date.
35. The construction contract is subject to the following conditions: (a) obtaining favorable long-term arrangements with AEC regarding fuel cycle and (b) obtaining a favorable long-term loan from Export-Import Bank covering capital cost.
36. The capacity of the Cuban plant (BANDES) includes about 17,000 kw(t) conventional superheat. The schedule is indefinite.
37. This TRIGA reactor was operated at the 1958 International Conference in Geneva prior to shipment to the University of Lovanium. The reactor began operating at the University of Lovanium in June 1959. It is the first reactor to be operated on the African continent.
38. This L-77 reactor was operated in the commercial exhibit of the 1958 International Conference in Geneva. It is presently in storage at Interatom, Inc.
39. The Netherlands research reactor was originally operated at the Amsterdam International Exhibition in June 1957. It is now in storage at Delft Technical University.
40. This reactor was operated in the International Science Section of the Brussels International Exhibition, April 15 to October 1, 1958, prior to transfer to the University of Basel.
41. AGN201-111 was operated in the commercial exhibit of the 1958 International Conference in Geneva prior to transfer to the University of Geneva.
42. This is the 1955 Geneva Conference reactor rebuilt with increased power and now operating at Wuerenlingen, Switzerland.
43. Bilateral agreement has not been executed.
44. Zero-power experiments of historical interest previously conducted in ANL facility cells include the Nautilus core design (ZPR-1), the Savannah River reactor design (ZPR-2), and a series of fast-neutron studies (ZPR-4) and interactions between two basic systems (ZPR-5).
45. The cell has one control panel but two pots. Experiments may be operated in either pot, but not simultaneously.
46. B&W cells 2 and 3 share a control panel with only one cell capable of being operated at any one time.
47. Solid-fuel cold critical (PWAR-5) experiments were conducted in the BMI facility in 1957.
48. Listed experiments were completed in 1959.
49. Test Reactor Assembly No. 1 and No. 2 were previously conducted in the GEANP facility.
50. PPA physics-data experiment was formerly located at Sacondaga Site, West Glenville, N. Y.
51. PMA at KAPL was modified from SIR Proof Test Reactor (PTR).
52. The NDA facility is designed to accommodate two experiments but has a present capability of one.

APPENDIX 3

COSTS OF NUCLEAR POWER

July 1959

INTRODUCTION

This report was prepared by the AEC Office of Operations Analysis and Forecasting. Numerous suggestions and data were provided by staff members of the AEC Divisions of Reactor Development and Finance. The report is intended only for information and discussion and does not necessarily represent an official position of the Atomic Energy Commission on any of the subjects covered. Comments, corrections, and additions from readers will be welcome.

The report is concerned only with stationary nuclear plants that are designed primarily for the generation of electricity. It considers data on the cost of electricity from those plants that are presently in operation, being built, or planned for early construction. It does not deal with studies of subsequent plants or the role of nuclear power in meeting long-term energy needs.

Principal sources of reactor information have been papers and books prepared for the Second International Conference on the Peaceful Uses of Atomic Energy at Geneva in September 1958, the Hearings in February 1959 before the Joint Committee on Atomic Energy, Congress of the United States, on Development, Growth, and State of the Atomic Energy Industry, the Directory of Nuclear Reactors issued by the International Atomic Energy Agency in June 1959, and other published reports and articles.

CAPITAL COSTS

This section deals with broad categories of capital cost for a nuclear power plant. Sources of information are estimates, bids, and actual costs in a few cases. The figures depend on reactor size, design, and location, degree of conservatism, time and purpose of the estimate or bid, and definition of items included in each cost category. Consequently, figures from different sources are often not comparable. Moreover, a breakdown of costs is not available for some projects. However, available data have been collected and are discussed below, capital costs for specific nuclear plants are given in Table 1, and a comparison of capital costs per installed kilowatt for nuclear and conventional steam plants is shown in Fig. 1.

LAND, SITE IMPROVEMENTS, AND STRUCTURES (INCLUDING CONTAINMENT)

The land area required for a nuclear plant is greater than for a conventional thermal plant of the same capacity, according to present safety rules. This is true even though the use of a containment structure as a safety measure reduces the extent of the denial area required for a nuclear plant. Containment measures may include a steel and concrete gas-tight structure around the reactor, air locks for entrances and exits, a ventilation and filter system, and a spray system. With additional operating experience, it may be possible to eliminate some of these measures or to reduce their costs. Other structures around those portions of a nuclear plant containing radioactive materials require shielding and are therefore more costly than corresponding structures for a conventional plant. From the data available for this study, the land, site improvement, and structural costs may vary from $40 to $210 per electrical kilowatt for large nuclear plants, compared with $6 to $55 per electrical kilowatt for large, modern, fossil-fuel plants as reported in the journal, *Electrical World*, for Oct. 7, 1957.

REACTOR AND STEAM GENERATING SYSTEM

This category includes the reactor pressure vessel and everything within it except the fuel elements. It includes cooling and moderator materials, such as heavy water, sodium, and graphite. It also includes equipment for controlling the reactor, handling fuel, supplying coolant, and disposing of waste, as well as heat exchangers, steam generators, pumps, piping, and instrumentation. (Boiling-water reactors operating on a single cycle to provide steam directly to the superheater or the turbine eliminate heat exchangers and steam generators.) The cost of the reactor and steam generating system for large plants currently ranges from $180 to $350 per kilowatt, compared with $40 to $85 per kilowatt for corresponding equipment in a large, modern, conventional plant. Increased power output and other technical improvements as well as manufacturing and operating experience over the next decade should result in significant reductions in capital costs per installed kilowatt in this category. For example, the Consolidated Edison Company of New York, Inc., has estimated that, if its plant under construction at Indian Point, New York, were duplicated at the same site, the cost of the nuclear portion would be reduced by one-third.

Table 1. CAPITAL COSTS OF SPECIFIC NUCLEAR POWER PLANTS

Plant	Status	Net electrical megawatts[a]	Capital cost in millions of dollars[b]	Dollars per net electrical kilowatt
Pressurized Water				
SM-1, Ft. Belvoir	Operable	1.9	3.8	2000
Obninsk (USSR)[c]	Operable	5	--	--
BR-3 (Belgium)	Being built	10.5	10.3	980
Shippingport	Operable	60[d]	73.4[e]	1220
Yankee	Being built	110[f]	51.4	470
SELNI (Italy)	Planned	160	50	310
Voronezh (USSR)[c]	Being built	196 (2)	--	--
Indian Point	Being built	255[g]	100[h]	390
Boiling Water				
EBWR	Operable	4.5[i]	4.6	1020
Vallecitos	Operable	5[i]	3.1[j]	620
JPDR (Japan)	Planned	11.7	8.6	740
RWE (Germany)	Being built	15	8.4	560
Elk River	Being built	22[k]	11.8	540
Humboldt Bay	Planned	46.5[l]	19.5	420
Ulyanovsk (USSR)	Being built	50[m]	--	--
Northern States	Being built	62[n]	20	320
Sverdlovsk (USSR)[c]	Being built	94 (4)[n]	--	--
SENN (Italy)	Planned	150	55[o]	370
Dresden	Being built	180	51[p]	280
Gas Cooled				
Oak Ridge	Planned	24	30	1250
AGR (UK)	Being built	28	--	--
Philadelphia Elec.	Planned	28.5[q]	25.7	900
Florida West Coast[r]	Planned	50	28.5	570
EDF-1 (France)	Being built	68	34	500
Berkeley (UK)	Being built	138 (2)	112[s]	410
Bradwell (UK)	Being built	150 (2)	122[s]	410
Hunterston (UK)	Being built	150 (2)	115[s]	380
Bohunice (Czech.)[t]	Planned	150[m]	--	--
JAPC (Japan)	Planned	166	80[t]	480
EDF-2 (France)	Being built	195	--	--
SIMEA (Italy)	Being built	200	73	360
Hinkley Point (UK)	Being built	250 (2)	168[s]	340
Heavy Water Cooled				
Carolinas-Virginia	Planned	17[u]	23	1350
NPD-2 (Canada)	Being built	19	26	1370
CANDU (Canada)	Planned	200	64[v]	320
Organic				
Piqua	Planned	11.4	9	790
Sodium Graphite				
SRE	Operable	5.7	9.6	1680
Ulyanovsk (USSR)	Being built	50[m]	--	--
Hallam	Being built	75[w]	50	670
Fast Breeder				
Dounreay (UK)	Operable	12	--	--
EBR-II	Being built	16.5	20[x]	1200
BN-50 (USSR)	Planned	50[m]	--	--
PRDC	Being built	94	53.5	570

Footnotes for Table 1

[a] Design capacity for initial operation. Where a nuclear power station includes two or more similar reactors, the capacity is given for one reactor with the number of reactors in parentheses.

[b] Not intended to include cost of research and development (other than that covered in a manufacturer's contract price) or costs of fuel inventory, fuel-element fabrication, substation, or transmission lines.

[c] Graphite moderated.

[d] Increase to 92 net electrical megawatts is planned without additional capital cost; increase to 135 net electrical megawatts is estimated for additional capital cost of $20 million.

[e] Does not include capitalized costs of $1.6 million, primarily prorated fuel-cycle cost, during performance test to prove out construction.

[f] To operate at 134 net electrical megawatts after the first core.

[g] Superheating with oil contributes 104 net electrical megawatts of the total.

[h] Estimated total cost, including cost of engineering, research, and development listed at $7.4 million.

[i] Limited by capacity of turbine-generator.

[j] Incremental cost at Vallecitos Atomic Laboratory of General Electric Co. Includes cost of fabricating first core.

[k] Superheating with coal contributes about 7 net electrical megawatts of the total.

[l] Gross electrical capacity is to be 50 megawatts initially and is to be increased to 60 megawatts in two years after startup.

[m] May be gross electrical megawatts.

[n] Includes nuclear superheat.

[o] From graph on page 96 of Nucleonics, March 1959.

[p] Includes contract price of $45 million, cost of land at $0.55 million, and overhead and interest during construction at $5.6 million.

[q] For metal-clad fuel elements. Power level for graphite-clad fuel elements is estimated to be 40 net electrical megawatts.

[r] Heavy-water moderated.

[s] Cost of a two-reactor station.

[t] From Atoms in Japan, May 1959.

[u] Includes superheating with oil.

[v] Includes cost of engineering and development.

[w] Increase to 87.5 net electrical megawatts is possible without additional capital cost.

[x] Does not include cost of fuel recycle plant.

STATION COST, DOLLARS PER ELECTRICAL KILOWATT

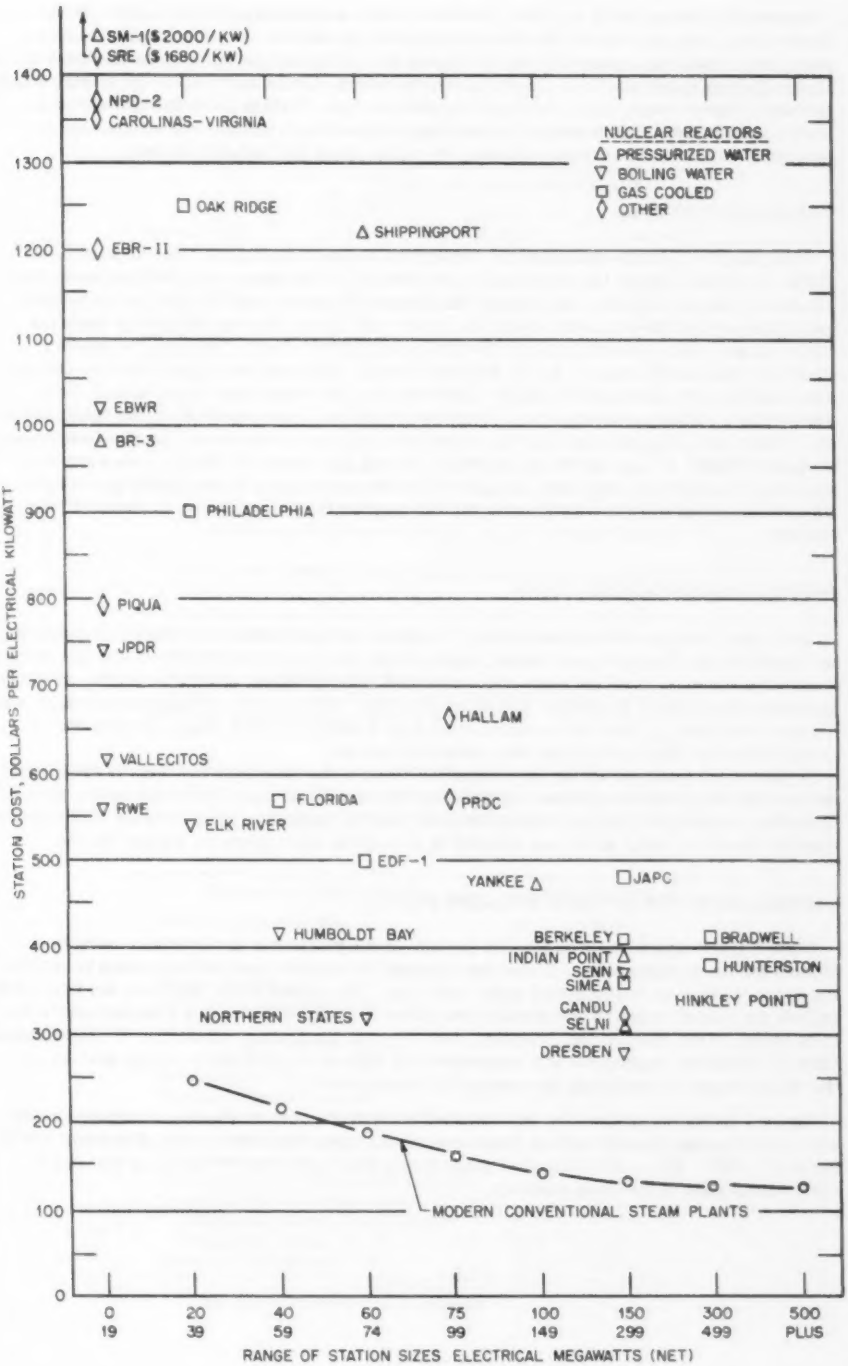

Fig. 1—Capital costs of power stations.

Superheating steam from a nuclear reactor or from a conventional boiler improves the thermal efficiency and usually the economy of power production. In the Indian Point nuclear plant, the steam is to be superheated by burning oil. In the nuclear plant of the Northern States Power Company at Sioux Falls, South Dakota, the steam is to be superheated by passing it back through a higher temperature portion of the reactor core. Further technical developments should permit significant increases in operating temperatures and thermal efficiencies of nuclear plants, with consequent reductions in capital costs per installed kilowatt.

TURBINE-GENERATOR

This category includes equipment for converting steam to electricity. For most nuclear plants of current design, the temperature and pressure of the steam produced are lower than for new conventional plants, the thermal efficiencies are lower, and the costs of the turbine-generator per installed kilowatt of electric power are higher. Turbine-generator costs for large nuclear plants considered here are $100 to $210 per kilowatt, whereas for modern fossil-fuel plants the range is $40 to $60 per kilowatt. Although the higher costs for nuclear plants are in part due to poorer steam conditions, in some cases they result in part from purchasing a turbine-generator with a capacity in excess of that required for the design output of the first core. For example, the net output of the reactor of the Power Reactor Development Company (PRDC) at Lagoona Beach, Michigan, during operation with the first core has been stated as 94 electrical megawatts, giving turbine-generator costs of about $130 per kilowatt. The turbine-generators are designed to net 145 megawatts, corresponding to about $85 per kilowatt.

MISCELLANEOUS CAPITAL COSTS

There are a number of cost items prior to and during construction that should be included in the capital costs. Examples are design, engineering, inspection, temporary offices and utilities, rental of equipment, field and home office expenses, payroll taxes, and fee or profit. An item of particular significance is interest during construction. For example, if construction funds cost 6% per annum and are spent at a uniform rate over a period of three years, interest during construction amounts to 9% of the total construction cost.

Expenses are incurred during the test period between the time when the plant is turned over by the constructor to the operator and the start of commercial operations. During the period of operations, working capital is required to cover current expenses. In most cases it is not clear whether these two items have been included in the capital costs given for nuclear plants.

CAPITAL COSTS FOR SPECIFIC NUCLEAR PLANTS

Table 1 gives capital costs of specific nuclear power plants that are operable, being built, or planned for early construction. These are arranged by reactor types and are listed in ascending order of net electrical capacity under each type. The capital costs listed are not intended to include the cost of research and development (other than that covered in a manufacturer's contract price) or the costs of fuel inventory, fuel-element fabrication, substation, or transmission lines. It should be emphasized that consistent cost figures are difficult to obtain and that caution is necessary in comparing the costs of different plants.

Figure 1 shows the capital cost per installed kilowatt for nuclear plants in comparison with a curve of average costs of modern fossil-fuel plants taken from the journal, *Electrical World*, for Oct. 7, 1957. The cost of a nuclear plant ranges from about two to six times the cost of a conventional plant of the same capacity.

ESTIMATES VERSUS ACTUAL COSTS

Estimates of the capital costs of specific nuclear plants have tended to increase with time. Where there is evidence on actual costs, they have tended to exceed the estimates. Some data on these points are given below.

Nuclear plant	Capital cost in millions of dollars		
	Original estimate	Current estimate	Actual cost
SM-1	1.9[a]		3.8
Shippingport	47.8		73.4
Yankee	32.9	51.4	
Indian Point	52.5	100[b]	
EBWR	3.6		4.6
Vallecitos[c]	3–4		2.5
Elk River	6.2[d]	11.8	
Piqua	5.6	9	
SRE[e]	3.5		7.3
Hallam	24.5	50	
PRDC	45.0	53.5	

[a] Accelerated construction schedule would have increased this to $2.1 million.

[b] Includes cost of engineering, research, and development listed at $7.4 million.

[c] Incremental cost at Vallecitos Atomic Laboratory of General Electric Co. Includes cost of first core but excludes $0.6 million for turbine-generator.

[d] Includes cost of fuel fabrication.

[e] Cost of reactor, not including power-generating equipment at $1.4 million or site and structures at $0.9 million.

There are undoubtedly many reasons for the increased capital costs given in the above table, and their relative importance probably varies from project to project. Consolidated Edison has explained the increases in the estimated costs of its Indian Point nuclear plant as follows:

Cost of conventional portion	Millions of dollars
Estimate of March 1955	36.5
Increase in gross capacity*	4.0
Escalation	3.5
Design changes	1.0
Estimate of September 1957	45.0
Cost of nuclear portion	
Estimate of March 1955	16.0
Increase in gross capacity*	2.7
Escalation	2.1
Waste disposal system	2.1
Safety requirements	3.2
Engineering, research, and development	7.4
Underestimate and design changes	6.8
Contingencies, overhead, and interest during construction	4.7
Estimate of September 1957	45.0

*From 236 to 275 electrical megawatts.

The cost increases resulting from increased gross capacity and escalation represent a situation that can also arise in the construction of fossil-fuel plants. In regard to the other items, much more basic nuclear research and development was involved than originally estimated and plans were modified a number of times, thereby increasing the cost of engineering. In addition, many items were underestimated and design changes increased the cost of the hardware, quickly eating up the original allowance for contingencies. The most recent cost estimate for the entire plant is about $100 million as the result of a further increase of $10 million, almost wholly attributable to price escalation.

VARIATIONS IN CAPITAL COST WITH DESIGN POWER LEVEL

It is apparent from Table 1 and Figure 1 that unit capital costs in dollars per installed kilowatt tend to decrease as the design power level increases. For example, estimated costs for boiling-water nuclear plants decline from $540 per kilowatt at 22 megawatts (Elk River) to $370 per kilowatt at 150 megawatts (SENN). Part of this variation is due to other factors than plant capacity in some cases. The larger nuclear plants listed tend to come later in time, so that improvements in technology are reflected in their estimated costs. Furthermore, none of the nuclear plants with design power levels above 60 electrical megawatts have been completed and, as indicated in the preceding section, estimated costs have tended to be less than finally realized costs.

Because of the limited experience with nuclear power and its changing state of technology, quantitative relationships between installed capacity and capital cost are not firm at the present time. For conventional thermal plants in the United States, average costs vary from $250 per installed kilowatt at 20 to 40 megawatts to $140 per installed kilowatt at 300 to 500 megawatts. Nuclear power could still be competitive at somewhat higher capital costs than these, if the sum of operating, maintenance, inventory, and fuel-cycle costs were lower for nuclear than for conventional plants. However, reduction in the present high capital costs of nuclear plants is a vital objective of the development program.

EFFECT OF SURPASSING THE DESIGN POWER LEVEL

A thermal power level of 60 megawatts has been attained in the Experimental Boiling Water Reactor (EBWR) at the Argonne National Laboratory in Illinois, compared with the design level of 20 megawatts; conversion to 100 megawatts is planned. The Vallecitos Boiling Water Reactor of the General Electric Company at Pleasanton, California, has operated at the maximum authorized level of 30 thermal megawatts, compared with the design level of 20 megawatts. These increases were possible because the power limits set by stability requirements are considerably higher than those initially imposed on the basis of the early Borax experiments. The limited capacity of the turbine-generators associated with those reactors do not permit increasing the electrical power levels accordingly. Additional capital investment in such facilities could lower the over-all capital cost per kilowatt of electrical capacity.

Significant increases in the power levels of large nuclear plants may be feasible. This is indicated by the planned increases in net electrical megawatts from 110 to 134 for Yankee, 94 to 140 for PRDC, and 60 to 92 for Shippingport, all without additional capital costs. A further increase from 92 to 135 net electrical megawatts for the Shippingport Atomic Power Station in Pennsylvania may be attained with a capital expenditure of $20 million.

Potential increases in the power level of the reactor of the Commonwealth Edison Company at Dresden, Illinois, are given on page 498 of the 1958 Geneva Conference book on *Boiling Water Reactors*. The design power level is 180 electrical megawatts, and the capital cost based on the contract price is $51 million or $283 per kilowatt. The reactor and the turbine-generator may be able to operate at about 5% above the design level with no additional capital investment, corresponding to 190 megawatts and $268 per kilowatt. The reactor core as originally designed may be capable of operating at 205 megawatts, the cost of an additional turbine-generator of 15 megawatts capacity is estimated at about $1.7 million, and the over-all capital cost would then be $257 per kilowatt.

A redesigned core, in which the diameter of the fuel elements is decreased in order to raise the thermal output without exceeding the central temperature limits of the fuel, may permit operation of Dresden at a power level of 245 megawatts; the cost of adding to the original turbine-generator a unit of 55 megawatts capacity is estimated to be about $6 million; and the over-all capital cost would then be $233 per kilowatt. All of the other equipment would be adequate for operation at this power level; the reactor recirculating and steam separating equipment can accommodate a 62% increase in primary steam flow without alteration. (An advanced station design of the Dresden type with a further redesign of core and increased pumping capacity and steam handling equipment might attain a level of 300 megawatts, and the capital cost per kilowatt would be further reduced.) It should be pointed out that the redesigned cores may well be more expensive to fabricate, so that a reduction in capital cost per kilowatt does not necessarily mean a reduction in the total cost of power.

THERMAL EFFICIENCY

The capital cost of a power plant per kilowatt of electrical capacity and the fuel cost per kilowatt hour depend on the thermal efficiency of the plant, which is defined as the ratio between the net electrical output and the heat output.* It depends on the temperature and pressure of the steam generated, the design and performance of the heat exchangers and the turbine-generator, and the amount of electric energy consumed in operating the plant itself. The operating efficiency may differ from the design efficiency because of such variables as the temperature of the condenser cooling water and standby time when fuel is being burned but no electricity is being generated.

The average thermal efficiency of conventional power plants has improved considerably over the years and is still improving. This is indicated by the following published data on the number of pounds of coal consumed per kilowatt hour of electricity generated.

	Pounds of coal per electrical kilowatt hour	
Year	Average for United States	Best new plants in United States
1905	5.7	3.6
1910	4.6	2.5
1915	3.8	1.9
1920	3.0	1.6
1925	2.0	1.2
1930	1.6	1.0
1935	1.44	1.0
1940	1.34	0.95
1945	1.30	0.85
1950	1.19	0.78
1955	0.95	0.73
Projected		
1960		0.70
1970		0.63
1980		0.58

*The heat output of a conventional plant is measured by the heat of combustion of all the fossil fuel used and includes energy lost through the furnace walls and the smokestack. The heat output of a nuclear plant is usually measured by the increase in energy content of the coolant in passing through the reactor and therefore does not include energy losses from the reactor. This makes thermal efficiencies of nuclear plants appear somewhat higher than they should when compared with conventional plants.

The efficiency of the best new plants burning coal in the United States has increased from about 8% in 1905 to about 40% at present. This has resulted from improving efficiency of combustion, reducing heat losses, and using steam at the higher temperatures and pressures made possible by improvements in the properties of materials. This technology is also available for nuclear power plants, but cannot be fully utilized at present because of additional requirements that must be met. The necessity of conserving neutrons, protecting the nuclear fuel while it is being burned, and confining the fission products means that structural, cladding, and alloying materials have to be developed not only to withstand thermal and corrosive effects but also to perform well under neutron irradiation. The result is that nuclear plants are not presently operating at the steam temperatures and pressures common for conventional power plants, which are around 1,000°F and 1,800 pounds per square inch. However, efforts are being made to improve nuclear plants in this regard. One method is to use gaseous coolants or liquid coolants with high boiling points. Another method is to superheat the steam, either by passing it through a higher temperature portion of the reactor or by heating it with fossil fuel.

Design efficiencies and steam conditions for a number of nuclear plants are listed in Table 2.

VARIATION IN CAPITAL COST WITH REACTOR TYPE

Each type of reactor now being seriously studied has potential advantages and disadvantages compared with other types. Some of these, such as safety, cannot be evaluated by the estimated cost of nuclear power. Furthermore, capital cost is only one item, although an important one, in the total cost of nuclear power; lower capital costs may be offset by higher fuel or operating costs. Although knowledge and experience to date do not enable firm, quantitative statements to be made, the following discussion indicates in a qualitative way some factors believed to be important in determining relative capital costs.

Water cooled and moderated reactors can draw on a large amount of engineering and operating experience with equipment handling water and steam under a wide range of temperatures and pressures. Pressurized light-water reactors are known to be feasible as the result of operating several units, military and civilian, and much of this experience is directly applicable to pressurized heavy-water reactors as well. Therefore, costs of research and development of new units may be reduced. The high heat-carrying capacity of liquid water permits the attainment of high power densities. However, existing pressurized-water reactors produce steam of substantially lower temperatures and have lower thermal efficiencies and higher turbine costs than do conventional thermal plants of modern design. The high pressures required to produce satisfactory steam conditions would increase the costs of the pressure vessel and associated equipment and would limit the size and power level of reactors. These limitations can be avoided by the use of a pressure-tube design, which will be tried in the reactor of the Carolinas-Virginia Nuclear Power Associates, Inc., at Parr, South Carolina, and in the NPD-2 in Canada, both being small heavy-water reactors. Use of nuclear or fossil-fuel superheat could raise the temperature of the steam and improve the thermal efficiency. The Consolidated Edison and Carolinas-Virginia plants will use oil-burning superheaters for this purpose.

Heavy water provides considerably better neutron economy than light water. However, the volume of moderator required is greater for heavy water than for light water, so that the size of the reactor and its capital costs are increased. In addition, the investment for the initial heavy-water inventory for a large reactor moderated and cooled with heavy water may be in the neighborhood of $45 to $75 per kilowatt. Finally, precautions taken to reduce losses of heavy water during operation tend to increase plant construction costs.

Boiling water reactors using light water have been demonstrated in small sizes. They have the advantage of operating at much lower pressures than pressurized water reactors while producing steam of the same or higher temperature. The high heat-transfer rate obtainable under conditions of nucleate boiling may permit high specific power, thus reducing the in-reactor inventory of fissionable material. For certain designs the presence of vapor bubbles may serve as an automatic safety feature in that loss of coolant supply reduces reactivity. Boiling light-water reactors using natural convection reduce the costs of pumps for coolant

Table 2. EFFICIENCY AND STEAM CONDITIONS FOR NUCLEAR POWER PLANTS

Plant	Design net efficiency, %	Steam conditions at outlet of nuclear steam generator	
		Temperature, °F	Pressure, psia
Pressurized Water			
SM-1, Ft. Belvoir	19	407	200
Obninsk (USSR)	17	500	184
BR-3 (Belgium)	26	471	508
Shippingport	27	486	600
Yankee	28	475	540
SELNI (Italy)	26	467	500
Vorenezh (USSR)	26	446	470
Indian Point[a]	26	449	420
Boiling Water			
EBWR	23	489	615
Vallecitos	25	545	1000
JPDR (Japan)	25	895	529
RWE (Germany)	25	497	663
Elk River[b]	26	531	890
Humboldt Bay	29	548	1025
Ulyanovsk (USSR)	20[c]	446	426
Northern States[d]	31	825	555
Sverdlovsk (USSR)[e]	33	950	1470
SENN (Italy)	30	543	990
Dresden	29	547	990
Gas Cooled			
Oak Ridge	28	900	1300
AGR (UK)	28	860	660
Philadelphia Elec.[f]	31	850	865
Florida West Coast	33	1000	1250
EDF-1 (France)	21	649	309
Berkeley (UK)	25	612	321
Bradwell (UK)	28	705	777
Hunterston (UK)	28	700	595
Bohunice (Czech)	25[c]	752	426
JAPC (Japan)	28	709	778
EDF-2 (France)	24	642	459
SIMEA (Italy)	28	703	770
Hinkley Point (UK)	26	685	655
Heavy Water Cooled			
Carolinas-Virginia[g]	--	503	700
NPD-2 (Canada)	22	450	415
CANDU (Canada)	25	419	304
Organic			
Piqua	25	880	440
Sodium Graphite			
SRE	27	825[h]	615
Ulyanovsk (USSR)	--	932	1320
Hallam	30	833	865
Fast Breeder			
Dounreay (UK)	17	525	200
EBR-II	26	850	1265
BN-50 (USSR)	--	788	470
PRDC	31	740	600

Footnotes for Table 2

[a] Oil-fired superheater raises the efficiency to 31%, delivering steam at 1000°F and 370 psia.
[b] Coal-fired superheater raises the efficiency to 30%, delivering steam at 825°F and 615 psia.
[c] Design gross efficiency.
[d] Includes nuclear superheat. Steam conditions before nuclear superheat are 489°F and 615 psia.
[e] Includes nuclear superheat. Steam conditions before nuclear superheat are 644°F and 1600 psia.
[f] For metal-clad core. Graphite-clad core is expected to provide an efficiency of 35% and steam conditions of 1005°F and 1500 psia.
[g] Oil-fired superheater raises the efficiency to 28%, delivering steam at 725°F and 415 psia. Information on the efficiency without the superheater is not available.
[h] Steam temperature of 970°F has actually been attained.

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circulation. Boiling heavy-water reactors, because of a much more rapid decrease in reactivity with percentage of steam in the moderator, may require forced circulation, and current designs are of this type. The elimination of the steam generator between the reactor and the turbine reduces capital costs, but places a more severe requirement on fuel element integrity to prevent radioactive contamination of the turbine by steam flowing directly from the reactor. Boiling water reactors appear to be more readily adaptable than pressurized water reactors to nuclear superheating. The Northern States plant will provide for nuclear superheating by recirculating the steam through the reactor. The plant of the Rural Cooperative Power Association at Elk River, Minnesota, will use a coal-fired superheater.

Organic cooled reactors may operate at pressures of one-eighth to one-tenth of those for boiling water reactors, while producing steam at the turbine of about the same temperature and quality. The radioactivity induced in the coolant is low and the corrosion is low, so that use can be made of ordinary steel and some items of conventional equipment. However, decomposition products may cause fouling of fuel elements and other heat transfer surfaces. The heat transfer properties of organic materials are inferior to those of water, so that the heat exchangers must be larger than for water reactors. The specific power and the power density of organic reactors are lower than for light-water reactors, resulting in larger fuel inventories and larger reactor cores. The lower cost of structural materials and equipment may more than balance the higher cost resulting from the greater size of the core, compared with water reactors. Additional considerations enter into the total cost of electricity, such as the cost of makeup of the organic material on the one hand and the savings in the cost of fuel element fabrication on the other hand.

Sodium cooled reactors operating at relatively low pressures can generate steam of temperature and quality comparable with the steam conditions in modern fossil-fuel plants. Heat-removal characteristics of sodium are excellent, permitting high specific powers. Because of the chemical reactivity of sodium and its high induced radioactivity, leak-tight systems are essential and add to the capital costs. Unless sodium is kept free of oxygen, corrosion may be severe. Although many cheap structural materials are resistant to corrosion by sodium, the present lack of large-scale commercial experience with sodium as a coolant means that development costs for special equipment will result in increased manufacturing costs. Sodium is not readily compatible with good moderators. Use of graphite may require that it be canned to prevent absorption of sodium, and use of heavy water poses problems of chemical incompatibility.

The principal advantage of the sodium-cooled fast-breeder reactor is the high breeding gain possible. The high power density of the core of a fast breeder requires the use of a coolant with the excellent heat-removal properties of sodium. The other advantages and disadvantages of sodium as a coolant in such a reactor are the same as discussed above, except that there is no moderator to pose compatibility problems.

Gas cooled reactors, operating at pressures of one-half to one-fourth of those for boiling water reactors, may permit the generation of steam of superheat comparable to that for modern fossil-fuel plants. Poor heat transfer and carrying properties of gas result in large,

and consequently expensive, reactor vessels and heat exchangers. The reactor vessels are particularly large if graphite is used as the moderator. Pressure-tube designs using heavy water as a moderator are considerably smaller. Gas-cooled graphite-moderated reactors can be designed so that their reactivity decreases markedly with increasing temperature, thus providing a very important safety factor. Graphite moderated and, to a greater extent, heavy-water moderated reactors can be designed to operate on natural uranium with a reasonable fuel life before reactivity limits are reached.

ANNUAL FIXED CHARGES

This section discusses the annual fixed charges on capital invested in power plants in the United States. These include the cost of money, depreciation, interim replacements, insurance, and taxes and are expressed as percentages to be applied against the initial plant investment. In order to obtain the contribution of annual fixed charges to the cost of power in mills per kilowatt hour, consideration is given to the plant factor which, together with the power capacity, determines the kilowatt hours generated per year.

COST OF MONEY

The national average for private financing of conventional thermal power plants corresponds to approximately 50% bonds, 15% preferred stocks, and 35% common stocks. The annual rates of return are taken as 4.5% for bonds, 5.0% for preferred stocks, and 9.57% for common stocks. This gives a weighted average of 6.35% in accordance with Technical Memorandum No. 1, Supplement No. 2 of Mar. 19, 1959, by the Bureau of Power, Federal Power Commission. This is the figure used in this report for privately-owned nuclear power plants.

Power plants owned by public utility districts are financed by money costing about 4.5% per annum. Power plants have been financed by the Rural Electrification Administration by loans bearing interest of 2% per annum.

DEPRECIATION

In making economic analyses of power projects, the Bureau of Power (FPC) uses an estimated service life of 35 years for conventional thermal power plants of modern design. We are taking a shorter period of 25 years for nuclear plants in order to make some allowance for special features of these plants, such as, irradiation effects. The annual fixed charge for depreciation also depends on the method used.

By the method of straight-line depreciation used by most of the privately owned utilities, equal allowances are made for depreciation each year and the undepreciated balance for a particular plant decreases correspondingly year by year.

By the sinking-fund method, a fixed amount of money is put into a fund each year, which draws interest and by the end of the depreciation period equals the initial capital cost of the plant. In determining the annual return on the plant investment, the initial value of that investment is regarded as applying during the period.

Because of the convenience of the sinking-fund method and because it gives approximately the same results as the average for the straight-line method, it is often used in studies of the cost of electric power and is adopted here.

INTERIM REPLACEMENTS

When the sinking-fund method is used, provision must be made for replacement of items of equipment having a life span less than the estimated service life of the plant. An average allowance equal to 0.35% of the plant investment is used for conventional thermal plants and the same allowance is assumed here for nuclear plants, although modification of this allowance may be necessary when substantial experience with full-scale commercial nuclear power plants becomes available.

INSURANCE

The annual cost of insurance for a conventional thermal plant ranges from 0.10 to 0.35% of the total plant investment. An average of 0.25% is used by the Bureau of Power (FPC). For a nuclear plant, insurance against nuclear hazards to the plant itself may add another 0.25%.

In addition, the law requires that private operators of nuclear plants having a capacity over 100 electrical megawatts purchase the full amount of liability insurance available from commercial sources, which is presently $60,000,000. The cost of this insurance depends on the location and safety characteristics of the nuclear plant and on use, thermal capacity, and containment. Annual premiums have been calculated for some plants and have ranged from 0.25 to 0.93% of the plant investment. Finally, the fee for indemnity up to $500,000,000 provided by the Federal Government for nuclear plants is $30 per year per thermal megawatt. This amounts to about 0.03% per year of the plant investment when the unit capital cost is $350 per installed electrical kilowatt, and a lower percentage for higher unit capital costs. The annual cost of liability insurance and indemnity together may therefore vary from about 0.3 to 1.0% of the plant investment.

The total cost of insurance for a nuclear plant may thus range from about 0.8 to 1.5% of the plant investment, and an average value of 1.0% is adopted here.

TAXES

Federal taxes other than income include old-age, unemployment, and excise taxes and amount annually to about 0.1% of the investment in privately-owned power plants. State and local taxes paid by privately-owned utilities generally include property, income, franchise, capital stock, gross earnings or receipts, occupation or license, energy or generation, unemployment, and excise taxes and amount each year to about 2.37% of plant investment on the average. About 65% of the total state and local taxes is property or ad valorem taxes.

For Federal income tax, the normal and surtax corporate rate amounts to 52% of the difference remaining after deduction from gross revenues of other taxes, all production costs (including those for operation, maintenance, and fuel), depreciation, insurance, and interest to bondholders. For the proportions of bonds and stocks and the rates of return assumed above, the annual Federal income tax would amount to 4.4% of the total plant investment. However, the Federal Revenue Act of 1954 permits the use of liberalized depreciation methods for income-tax purposes in regard to depreciable plant investment made after Dec. 31, 1953. Many privately-owned utilities have adopted such methods, with the result that part of their annual income-tax payment is deferred during the first portion of the depreciation period. Even when tax deferrals are added to the taxes paid, there are large variations in annual Federal income taxes from one company to another, the range being from about 2% to about 6% of the plant investment. The Bureau of Power (FPC) has found the national average to be 3.57% and that figure is used here.

This treatment of income taxes assumes that, in the period prior to economically competitive nuclear power, the added costs will be included in the rate structure and passed on to the consumers of electricity. Where this is not the case, installation of a non-competitive nuclear plant rather than a conventional plant will reduce the corporate income and the income taxes paid.

For power plants financed by public utility districts, there are no Federal income taxes and we have taken other taxes to be about 1.1% of plant investment. For power plants financed by the Rural Electrification Administration, there are also no Federal income taxes and we have taken other taxes to be about 0.5% of plant investment.

TOTAL ANNUAL FIXED CHARGES ON PLANT INVESTMENT

Annual fixed charges as percentages of plant investment are summarized and totaled in the following table. Where these charges are different for a conventional thermal plant than for a nuclear plant, the first entry is for a nuclear plant and the one in parentheses is for a conventional plant.

	Type of financing		
	Private company	Public utility district	Rural Electrification Administration
Cost of money	6.35%	4.5%	2.0%
Depreciation	1.73 (0.83)	2.24 (1.23)	3.1 (2.0)
Interim replacements	0.35	0.35	0.35
Insurance	1.0 (0.25)	1.0 (0.25)	1.0 (0.25)
Federal income taxes	3.57	0	0
Other taxes	2.47	1.1	0.5
Total	15.5 (13.8)	9.2 (7.4)	7.0 (5.1)

PLANT FACTOR

In order to compute the contribution of annual fixed charges to the unit cost of electric energy, it is necessary to estimate the number of kilowatt hours generated by a given plant each year. This is determined by the product of the time during which the plant is operating and the average power level during operation. When expressed as a percentage of the energy that would have been generated if the plant had operated continuously at full capacity, this is called the plant factor.

The plant factor for a nuclear plant is determined by the technical capability of the installation, by the demand for electric energy, and by the relative operating costs of the nuclear plant and conventional plants in the same system. On the basis of considerable experience with production reactors and very limited experience with power reactors, it is often assumed that a nuclear plant, after an initial test period, would be technically capable of attaining a plant factor of 80%, allowance being made for scheduled and unscheduled shutdowns and reductions in power. If high irradiation levels are reached without fuel-element failures, the frequency of charging and discharging the reactor core will be much lower than for existing production reactors. Power reactors under construction in the United Kingdom, utilizing uranium metal as fuel and having a lower irradiation level than is expected for most United States power reactors, are designed for charging and discharging fuel elements while the reactor is operating. Without that feature, the plant factor up to September 1958 was 67% for the first Calder Hall reactor and 81% for the second one. The average plant factor for the Shippingport reactor was slightly above 30% during 1958, the first year after attaining criticality; for a three months' period ending on Sept. 30, 1958, the plant factor was 56.6%.

The demand for electric energy experienced by any public utility varies with the hour of the day and the day of the year. However, there is a base load representing the minimum demand to be met at all times. For large utilities, the base load is sufficient to require the operation of several power generators, the choice depending on the relative operating and transmission costs. If the capacity of the nuclear plants in a given system is within the base load of that

system and if the operating and transmission costs are less for the nuclear plants than for the conventional plants in the system, then the nuclear plants would be operated at as high a plant factor as they were technically capable of. Even with favorable operating costs relative to conventional plants, the average plant factor for nuclear plants will start to decrease when their total capacity exceeds the base load. Because of the higher annual fixed charges for nuclear plants, they will then find it harder to compete with conventional plants.

FIXED CHARGES IN MILLS PER KILOWATT HOUR

The contribution of annual fixed charges to the cost of electricity in mills per kilowatt hour for nuclear plants is illustrated in the table below.

	Fixed charges in mills per kilowatt hour				
	Plant investment per kilowatt				
	$200	$400	$600	$800	$1000
Private Company					
Plant Factor					
20%	17.7	35.4	53.1	70.8	88.5
40%	8.9	17.7	26.6	35.4	44.3
60%	5.9	11.8	17.7	23.6	29.5
80%	4.4	8.9	13.3	17.7	22.1
Public Utility District					
Plant Factor					
20%	10.5	21.0	31.5	42.0	52.5
40%	5.3	10.5	15.8	21.0	26.3
60%	3.5	7.0	10.5	14.0	17.5
80%	2.6	5.3	7.9	10.5	13.1
Rural Electrification Admin.					
Plant Factor					
20%	8.0	16.0	24.0	32.0	40.0
40%	4.0	8.0	12.0	16.0	20.0
60%	2.7	5.3	8.0	10.7	13.3
80%	2.0	4.0	6.0	8.0	10.0

FUEL-CYCLE COSTS

This section deals with the costs of the fuel cycle for nuclear power plants. Included are the cost of fabricating the fuel elements, the cost of shipping irradiated fuel, the cost of chemical reprocessing of irradiated fuel and chemical conversion of the special nuclear materials recovered, the cost of fuel burnup, and the credit for plutonium and U^{233} produced. (Inventory charges and the costs of operation and maintenance, including the cost of moderator and coolant makeup, are discussed in subsequent sections.) In order to express fuel-cycle costs in mills per kilowatt hour of electricity generated, it is necessary to consider first the irradiation level of nuclear plants.

IRRADIATION LEVEL

The irradiation level is given in terms of the megawatt days of heat generated per *metric ton of uranium* in the reactor (Mwd/ton). Increasing the irradiation level reduces the annual throughput of fuel and the annual cost of fabricating, shipping, and reprocessing fuel elements of a fixed design. However, fuel elements capable of withstanding higher irradiation levels may be more expensive to fabricate and reprocess. Moreover, the enrichment of the fuel may have to be increased in order to maintain reactivity, with the result that burnup and inventory charges are raised. The consumption of plutonium or U^{233} generated in the reactor increases with the irradiation level, and the effect on fuel-cycle costs depends on the prices of these materials compared with the primary fuel (usually U^{235}).

Plans for reactors using natural or somewhat enriched uranium are usually based on attaining average irradiation levels in the range of 3,000 to 13,000 Mwd/ton. Warranties of fuel-element performance may be given by manufacturers.

In the joint program of the United States and Euratom for the installation of a nuclear power capacity of 1,000,000 electrical kilowatts in the Euratom countries, the United States is offering standard fuel-element guarantees of an irradiation level of 10,000 Mwd/ton and a fabrication charge of $100 per kilogram of uranium when clad with stainless steel or $140 per kilogram of uranium when clad with zirconium, the fuel being uranium oxide with U^{235} assays not greater than 3% and diameters between 0.25 and 0.50 inches. For U^{235} assays between 3% and 5%, the corresponding fabrication charges are increased by $8 for each percentage above 3%. For other irradiation levels and fabrication charges, the guarantees are adjusted to give an equivalent fuel-cycle cost.

Peak irradiation levels, often occurring in the center of a reactor, may be several times greater than the average irradiation level for the reactor as a whole. In small-scale experiments, zirconium tubes containing enriched uranium-oxide pellets have been irradiated to 30,000 Mwd/ton without deleterious effects. Enriched uranium oxide dispersed in stainless steel and enriched uranium metal alloyed with zirconium have been irradiated to similar levels with good dimensional stability. The irradiation level for normal uranium-oxide pellets in zirconium tubes in the Shippingport reactor has reached an average of about 2,000 Mwd/ton and a peak of about 10,000 Mwd/ton. (The peak occurs near the highly enriched seed.) As ex-

perience increases and technology improves, irradiation levels may be expected to exceed present guarantees.

COST OF FUEL-ELEMENT FABRICATION

Fuel-element fabrication is taken to include all steps in the manufacture of completed fuel elements, including chemical, metallurgical, and mechanical processing, inspection, testing, and waste recovery. The cost of fabrication per unit mass of uranium depends on the design of the fuel element, its size, dimensional tolerances and other specifications, enrichment of the uranium, kind of alloying and cladding materials, number of fuel elements fabricated, and inventory charges. For example, uranium-oxide pellets as formed may cost one-third less than pellets ground to precise tolerances. Utilization of more highly enriched uranium increases criticality hazards and necessitates the use of batches of smaller size, thereby increasing unit costs.

Estimates of fuel fabrication cost are not always clearly defined. In compiling the table below, the fabrication cost for the first core is divided by the number of kilograms in the core to obtain the unit cost shown.

Plant	Fuel and cladding	U^{235} assay, %	Uranium in core, kg	Fuel fabrication cost, $ millions	Unit fuel fabrication cost, $/kg of U
EBWR	U–Zr–Nb, Zircaloy-2	1.44*	5,700	0.8	140
Humboldt Bay	UO_2, Zircaloy-2	1.9	14,000	3.0†	210†
Yankee	UO_2, Stainless Steel	3.02‡	21,400	3.6	170
SRE	U Metal, Stainless Steel	2.78	3,000	0.33	110
Piqua	U–Mo, Aluminum	1.8	6,600	0.46	70

* Of the 114 fuel assemblies, 8 contain normal uranium and 106 contain uranium having a U^{235} assay of 1.44%.

† Maximum for first core. Second core is expected to cost less than $2 million or $140/kg of U.

‡ Recently changed to 3.4%.

The charges for fuel-element fabrication on which the standard fuel-cycle costs are based in the arrangement with Euratom are $100 per kilogram of uranium clad with stainless steel and $140 per kilogram of uranium clad with zirconium, for uranium oxide with U^{235} concentrations not greater than 3% and diameters between 0.25 and 0.50 inches.

The costs of fabricating enriched uranium into fuel elements to meet specified standards of performance should decrease substantially as a result of technological improvements and large-scale production. However, increasing the irradiation levels and temperatures to be attained may have an opposite effect, at least temporarily.

COST OF TRANSPORTING IRRADIATED FUEL ELEMENTS

As an example of the cost of transporting irradiated fuel elements from the reactor site to the chemical reprocessing plant, a situation similar to that for the reactor of the Yankee Atomic Electric Company at Rowe, Massachusetts, is considered. It is assumed that the cool-

ing time between discharge of the fuel elements from the reactor and their shipment is 120 days or more, that the weight of the shipping cask is 60,000 pounds, and that the weight of irradiated uranium in each shipping cask is 2,000 pounds. It is further assumed that four casks are required but that they are used for fuel from one reactor for a total time of only three months each year. This means that it may pay the reactor operator to rent casks rather than buy them. Insurance during shipment is taken as 2% of the value of the special nuclear material in the fuel elements. The costs are then as follows:

	Dollars per kilogram of uranium
Freight from New England to Hanford	2.80
Freight from Hanford to New England (return of empty casks)	1.40
Cask rental	1.30
Courier charge	0.50
Insurance	4.00
Total	10.00

For a reactor in Western Europe, costs for shipment of irradiated fuel elements from Hamburg to Hanford have been taken in some of the Euratom calculations as $20 per kilogram of contained uranium. This was based on smaller shipping casks having a higher ratio of the weight of cask to the weight of contained uranium and included costs of ocean freight and a higher courier charge than in the above table.

The factors that contribute most to the uncertainties in these transportation costs are the amount of insurance, the choice of cask size and weight, cooling time prior to shipment, and effect of negotiations on carrier rates.

COST OF CHEMICAL REPROCESSING AND CONVERSION

After irradiation and cooling, fuel elements undergo chemical reprocessing to extract source or special nuclear materials. A notice by the AEC in the Federal Register of Mar. 12, 1957, established charges for chemical reprocessing based on an assumed plant with a capacity of one ton per day for normal or slightly enriched uranium and a reduced capacity for more highly enriched uranium. The basic charge was set at $15,300 for each day of plant operation required to process a batch of fuel elements, plus a charge to cover start-up, shutdown, and clean-up of the process system between batches and a charge to cover process losses. AEC charges for fuel elements of several types are shown in the table below.

Reactor	Fuel-element type	Reprocessing site	AEC charge, $/kg U
Dresden	UO_2, zirconium clad, 1.5% U^{235}	Hanford	24
Yankee	UO_2, stainless-steel clad, 2.6% U^{235}	Hanford	21
Hallam	U-Mo alloy, stainless-steel clad, 2.5% U^{235}	Hanford	20
PRDC	Blanket, U-Mo alloy zirconium clad, depleted U	Hanford	19
PRDC	Core, U-Mo alloy, zirconium clad, 27% U^{235}	Savannah River	139
Con. Edison	UO_2-ThO_2, stainless-steel clad, 90% U^{235}	Oak Ridge	1240

The AEC has reserved the right to terminate chemical reprocessing services when it determines that such services are commercially available at reasonable prices. Commercial prices will be greatly dependent on the technology used, the scale of operation, and the rate of plant amortization. Expanded uses for radioactive fission products may permit their profitable recovery from power-reactor fuel elements.

The product of the chemical reprocessing plants is usually purified solutions of uranium nitrate and of plutonium nitrate. The charge by the AEC for converting uranium nitrate to hexafluoride is currently $5.60 per kilogram of uranium for U^{235} assays of 5% or less and $32 for assays above 5%. The charge by the AEC for converting plutonium nitrate to metal is $1.50 per gram.

COST OF U^{235} BURNUP

Enriched uranium is leased domestically by the AEC, but the user pays for material lost or consumed. The fraction of the contained U^{235} consumed prior to discharge of fuel elements depends on the reactor design, the initial U^{235} assay, and the irradiation level. The initial and the final assays determine the unit cost of burnup, which can be computed from the schedule of charges announced by the AEC on Nov. 18, 1956. The burnup cost is the difference between the charge for the uranium hexafluoride in fresh fuel and the credit for uranium recovered from irradiated fuel and converted back to the hexafluoride. The unit cost of burnup increases with the initial U^{235} assay and decreases as the irradiation level goes up. The variation with irradiation level is greater for normal and slightly enriched uranium than for higher assays and is quite small for highly enriched uranium.

For example, consider fuel elements containing uranium oxide clad with stainless steel for use in a pressurized-water reactor of the Yankee type. The initial U^{235} assay is around 3% and the assay after irradiation to 8,200 Mwd/ton is estimated as about 2.25%. The U^{235} burnup cost is then $15.60 per gram consumed.

Another example is for fuel elements containing uranium oxide clad with a zirconium alloy for use in a boiling-water reactor of the Dresden type. The initial U^{235} assay is around 1.8% and the assay after irradiation to 11,000 Mwd/ton is estimated as about 0.9%. The U^{235} burnup cost is then $14.20 per gram consumed.

CREDIT FOR PLUTONIUM AND U^{233}

Under the Atomic Energy Act, any special nuclear material within the United States is the property of the United States and a fair price shall be paid to any person lawfully producing such material. The domestic price in effect for plutonium delivered to the AEC through June 30, 1962, is shown below:

Percent of Pu^{240}	Price of plutonium metal, $/g
0	45.00
2	41.50
4	38.00
6	34.50
8	31.00
8.6 and over	30.00

The domestic price is $30 per gram of plutonium metal, regardless of isotopic composition, delivered to the AEC during the period of July 1, 1962, through June 30, 1963. The price for plutonium metal purchased by the AEC from foreign countries and restricted to peaceful uses is currently $12 per gram, based on an estimated value of plutonium compared with enriched

uranium as fuel for reactors operating on neutrons of thermal energy. The AEC price for U^{233} domestically and for foreign purchases is $15 per gram of U^{233} in the form of the nitrate.

An important question in regard to the development of economic nuclear power is whether a particular plutonium price will remove incentives for attaining high irradiation levels of fuel elements. This depends on other costs in the fuel cycle, such as the costs of fuel-element fabrication and chemical reprocessing. Consideration of Yankee and Dresden type reactors indicate that, for plutonium prices of $30 or less per gram of metal and fuel-element fabrication costs of $100 or more per kilogram of uranium, the net cost of the fuel cycle decreases with increasing irradiation level throughout the operating range presently anticipated. For much higher plutonium prices or much lower fuel-element fabrication costs, the curve of net fuel-cycle cost versus irradiation level may pass through a minimum in the anticipated operating range, where it would be economic to discharge the fuel elements.

Another important aspect of a plutonium price is its effect on the economics of recycling plutonium as a reactor fuel. There would be no immediate economic incentive to recycle plutonium in power reactors if the plutonium could be sold at a price higher than its fuel value. However, there would still be strong incentives to develop methods of recycling plutonium in anticipation of a time when its fuel value would prevail.

A high price for plutonium tends to favor reactors with a high ratio of plutonium formation to U^{235} burnup, such as heavy water or fast reactors. A high price for plutonium compared with the price for U^{233} tends to discourage the construction of reactors producing U^{233}.

TOTAL FUEL-CYCLE COSTS

The base case chosen for computation of total fuel-cycle costs is a pressurized water reactor of the Yankee type, having a thermal efficiency of 28%. The fuel elements are assumed to be clad with stainless steel and to contain uranium oxide with such U^{235} assays as are necessary to provide reactivity for achieving given irradiation levels.* Costs per kilogram of uranium are taken to be $100 for fabricating fuel elements, $10 for transporting irradiated fuel elements from the reactor to the chemical reprocessing plant, and $27 for chemical reprocessing plus conversion of uranium nitrate to hexafluoride. The price for plutonium is taken as $12 per gram minus $1.50 for conversion from nitrate to metal.

		Cost in mills per kilowatt hour					
Irradiation level, Mwd/ton	Initial U^{235} assay, %	Fuel element fabrication	Transport	Chemical processing & uranium conversion	U^{235} burnup	Pu credit	Total
2,000	2.33	7.44	0.74	2.01	3.28	−1.32	12.15
4,000	2.48	3.72	0.37	1.00	2.64	−1.14	6.59
6,000	2.60	2.48	0.25	0.67	2.50	−1.08	4.82
8,000	2.77	1.86	0.19	0.50	2.36	−1.01	3.90
10,000	2.90	1.49	0.15	0.40	2.29	−0.94	3.39
12,000	3.05	1.24	0.12	0.33	2.23	−0.85	3.07
14,000	3.20	1.06	0.11	0.29	2.17	−0.77	2.86

If the thermal efficiency were increased from 28% to 35%, all of the costs in the above table would be reduced by 20%, decreasing the total cost of electricity by from 2.4 to 0.6 mills per kilowatt hour. For a plutonium price of $30 instead of $12 per gram of metal ($28.50 instead

*Based on a progress report on the Fuel Cycle Study Project at the Massachusetts Institute of Technology.

of $10.50 per gram of nitrate), the plutonium credits in the table would be multiplied by 2.7 and the total cost of electricity would be decreased by from 2.3 to 1.3 mills per kilowatt hour.

The use of zircaloy instead of stainless steel for cladding fuel elements provides greater neutron economy. This can be used to increase the ratio between plutonium formation and U^{235} burnup. It also permits the attainment of a given irradiation level with uranium fuel having a lower initial assay of U^{235}. For the Yankee type reactor considered above, uranium-oxide fuel clad with zircaloy would have sufficient reactivity to reach 10,000 Mwd/ton if the initial U^{235} assay were approximately 2%, compared with 2.9% for fuel clad with stainless steel. The corresponding assay for 14,000 Mwd/ton is 2.25% for zircaloy cladding instead of 3.2% for stainless steel cladding. The result is to reduce the cost of U^{235} burnup by roughly 0.4 mills per kilowatt hour for irradiation levels in the range of 5,000 to 15,000 Mwd/ton.

A disadvantage of zircaloy is the possibility of reaction with water in the event that fuel element jackets are accidentally melted. This possibility cannot be entirely eliminated on the basis of presently available information. Another disadvantage is that zircaloy costs more than stainless steel. The savings of 0.4 mills per kilowatt hour in the cost of U^{235} burnup obtained by using zirconium cladding would be just offset if the difference in fabrication cost between zirconium and stainless-steel clad fuel elements were $27 per kilogram of uranium at 10,000 Mwd/ton or $40 per kilogram at 15,000 Mwd/ton. The corrosion resistance of both stainless steel and zircaloy are believed to be satisfactory from the standpoint of fuel-element integrity. There has been some evidence of radioactivity from the corrosion products of stainless-steel jackets.

INVENTORY CHARGES

For nuclear power plants of the types now being planned and built, there will be a large investment in fuel being irradiated and in the pipeline of materials in various stages of fabrication of fresh fuel elements and reprocessing of spent fuel elements. In addition, heavy water reactors may require an investment of up to perhaps $75 per kilowatt for their heavy water inventory. A carrying charge on the investment in these inventories must be included in the cost of nuclear power. This is frequently estimated by taking a fixed percentage of the value of the inventory. With increasing experience, the estimation of inventory charges will probably become more sophisticated, taking into account different charge rates applicable to the various components and actual time intervals between expenditures and revenues.

FUEL-CYCLE INVENTORY

The value of the fuel-cycle inventory depends on the design of the particular reactor, its mode of operation, and the procedure followed in evaluating the fuel elements as they pass through the cycle. However, the larger value of this inventory is indicated in the following table.

Plant	Capacity Mw(e)	U^{235} assay	Value of fuel-cycle inventory in dollars per electrical kilowatt: Initial value of uranium	Average value of fuel elements
Yankee type (pressurized water)	134*	2.9%	120	116
Dresden type (boiling water)	180	1.8%	84	92
U.K. type (gas cooled)	150	Normal	57	46

* For the second core.

In the above table, the initial value of the uranium inventory is based on the published United States schedule of charges. The average value of fuel elements is taken as one-half of the sum of the total value of the fresh fuel elements that could be made from the uranium in the inventory and their salvage value after irradiation. The salvage value for fuel elements from the United States reactors takes account of the remaining uranium, credits the plutonium on the basis of its fuel value, and includes deductions for transportation, chemical reprocessing, and conversion charges. For the United Kingdom gas cooled reactor, the United Kingdom credit for spent fuel elements was used.

The annual carrying charge on the inventory includes the cost of money, insurance, and taxes. If the value of the uranium in the fuel-cycle inventory is considered to be a nondepreciating asset and if appropriate adjustments are made for taxes and insurance, the annual

fixed charge of 15% on plant investment can become about 12% on the inventory investment. Under AEC lease, the use charge for the value of the uranium in the inventory is 4% per annum. In evaluating the bids under the SENN project, an International Panel applied a rate of 7% per annum to the initial value of the whole fuel inventory. As extreme cases, to indicate the magnitude of the fuel-cycle inventory charge, consider rates of 4% and 12% per annum applied to the initial value of the uranium estimated for the Yankee-type reactor considered above. This results in charges of about 0.7 and 2.1 mills per kilowatt hour, respectively, on the basis of a plant factor of 80%.

HEAVY-WATER INVENTORY

The cost of the heavy water inventory is included in the plant investment. Considerations determining the inventory charges for heavy water are similar to those applicable to the fuel cycle, although the preparation, use, and recovery of heavy water is not as complex as for uranium. Some designs for heavy water reactors have indicated an inventory cost for heavy water, based upon the United States current price of $28 per pound, of about $45 to $75 per kilowatt. On this basis, the heavy water inventory charge would be about 0.25 to 0.43 mills per kilowatt hour if heavy water is leased at 4% per annum or 0.75 to 1.30 mills per kilowatt hour if an inventory charge of 12% per annum were to apply.

COST OF OPERATION AND MAINTENANCE

GENERAL

There is not yet much information on the cost of operation and maintenance of nuclear power plants under commercial conditions. The Shippingport station had the following expenses in this category during a three months' period ending on Sept. 30, 1958. The plant factor during this period was 56.6%.

	Reactor & steam generator	Turbine-generator	Total Dollars	Total Mills per kw-hr
Operations				
Station labor	$107,470	$ 65,080	$172,550	2.29
Supplies, health, safety, etc.	88,391	25,234	113,625	1.51
Maintenance				
Supervision and engineering	7,621	6,973	14,594	0.19
Structures and improvements	4,006	3,988	7,994	0.11
Reactor and Steam generating equipment	42,735	5,471	48,206	0.64
Generating and electric equipment	12,145	15,373	27,518	0.36
Total for operations and maintenance	262,368	122,119	384,487	5.10

Since the Shippingport reactor is the first of its kind and since the plant is being used for experimental purposes, these costs are not expected to be representative of commercial stations. The costs in mills per kilowatt hour depend on the plant factor, which is usually assumed to be 70 or 80% for nuclear plants. A Euratom calculation used 2 mills per kilowatt hour as the cost of operation and maintenance for nuclear power plants of the pressurized-water type, compared with 1 mill per kilowatt hour for fossil-fuel plants. A du Pont study of heavy water reactors sets this cost at 2.0 mills per kilowatt hour for a 100-megawatt plant and 1.2 mills for a 250-megawatt plant (not including losses of heavy water). Consolidated Edison has allowed 0.9 mills per kilowatt hour for operation and maintenance of the Indian Point plant, compared with 0.63 mills for the actual cost at a fairly new conventional steam plant, but has indicated that years of operation are required before there will be a sound basis for estimating such costs in the nuclear case.

An industrial study group, consisting of American Gas and Electric Service Corporation, Bechtel Corporation, Commonwealth Edison Company, Pacific Gas and Electric Company, and Union Electric Company of Missouri, in 1955 made the following estimate of the cost of operation and maintenance for a completely independent nuclear power plant having a net elec-

trical output of 180 megawatts. The total number of employees was taken as 136, consisting of 69 supervisory and administrative, 29 operating, and 38 maintenance personnel. Included were four health physicists, two health-physics technicians, thirteen security police, a doctor, and a nurse.

Estimated annual cost

Supervision and administration	$ 397,050
Operations	142,600
Maintenance, labor	187,800
17% of above costs for payroll taxes, injuries and damages, pensions, employee welfare	124,000
Maintenance materials	135,000
Supplies and miscellaneous	54,000
Total	$1,040,450

For a plant factor of 80%, the cost of operation and maintenance in this case would be 0.83 mills per kilowatt hour.

An Oak Ridge National Laboratory study of a slightly enriched, gas cooled reactor having a net electrical output of 225 megawatts included the following estimate of the cost of operation and maintenance.

Estimated annual cost

Wages, including supervision (100 men @ $6,000/yr)	$ 600,000
Water, lubrication, helium, and supplies	400,000
Maintenance	400,000
Total	$1,400,000

For a plant factor of 80%, the cost of operation and maintenance in this case would be 0.89 mills per kilowatt hour.

The cost of operation and maintenance will depend on the type of nuclear power plant, the state of development incorporated in its design, and operating experience with the plant. Estimates made in advance of acquiring such experience will continue to be uncertain.

MODERATOR AND COOLANT MAKEUP

The cost of moderator and coolant makeup is applicable to those reactors that incur losses of such materials having appreciable value. The losses may be economically significant for reactors cooled or moderated with heavy water or organic liquids. For reactors cooled with liquid metals or gases, the cost of coolant makeup is thought to be relatively small.

Annual losses of heavy water in a pressurized reactor studied by the Carolinas-Virginia group were estimated at 1% of the heavy water inventory, resulting in a contribution to the cost of power of 0.08 mills per kilowatt hour. A Canadian study of a reactor having a capacity of 200 electrical megawatts assumed that the cost of heavy water replacement and upgrading was about 2% of the cost of the heavy water inventory and made a contribution of about 0.15 mills per kilowatt hour to the cost of electricity. A study by the General Nuclear Engineering Corporation assumes an annual loss of 4% of the heavy water inventory and a cost of 0.3 mills per kilowatt hour. Du Pont studies indicate a contribution of heavy water losses to the cost of electricity equal to 0.7 mills per kilowatt hour for a plant having a capacity of 100 electrical megawatts and 0.4 mills per kilowatt hour for a plant having a capacity of 250 electrical megawatts, although these costs varied with the design.

Experience with the Organic Moderated Reactor Experiment in Idaho, which is cooled and moderated by an organic liquid, has shown a makeup rate of about 0.002 pounds of the organic material per thermal kilowatt hour. This makeup rate is equivalent to replacing the entire inventory of organic material twice each year. At a cost of $0.20 per pound of the material and a thermal efficiency of 30%, this would amount to 1.3 mills per electrical kilowatt hour. However, the makeup cost for a large power reactor is expected not to exceed 0.7 mills per kilowatt hour.

TOTAL COST OF NUCLEAR POWER

Because of the many variables and uncertainties discussed in the preceding sections, no firm answers can be given at this time for the total cost of nuclear power. Summarized below is a range of expected costs of electricity from those nuclear plants being built or planned for early construction, utilizing a pressurized-water or a boiling-water reactor, and having a net capacity of 150 electrical megawatts or more. (Although no organic cooled reactor of this size is presently under construction, it would probably give costs in the same range.) The annual fixed charge on plant investment is taken as 15.5%. The annual inventory charge is assumed to be 4% of the value before irradiation of the enriched uranium in the reactor and the pipeline.

Plant investment per net electrical kilowatt	$300–$400
Plant factor	80%–70%
Cost in mills per kilowatt hour	
Fixed charges on plant	6.5–10.0
Fuel-cycle costs	3.0–5.0
Inventory charge	0.5–1.0
Operation and maintenance	1.0–2.0
Total	11.0–18.0

These expected costs for nuclear plants may be compared with current costs for conventional power plants. The journal, *Electrical World*, for Oct. 7, 1957, gave cost data for 44 modern steam stations in the United States; the 12 that had generating units in the range of 100 to 300 electrical megawatts and annual fixed charges of 12.6 to 15.7% of the plant investment gave total costs of electricity of 5.5 to 8 mills per kilowatt hour. In the Euratom countries, costs of electricity from new fossil-fuel plants having a capacity of 150 electrical megawatts have been estimated to be between 9 and 11 mills per kilowatt hour. It is clear that the costs estimated above for nuclear plants are not yet competitive with costs for conventional plants either in the United States or generally in the Euratom countries.

The largest single factor in the cost of electricity from these nuclear plants is the high fixed charges arising from the high capital investment. This effect may be somewhat reduced if the plants can operate above their design power levels. Where a utility system can justify the installation of a nuclear plant having a design capacity considerably greater than 150 electrical megawatts, the fixed charges in mills per kilowatt hour should be significantly less than those given above. Technological improvements and standardization of design should also reduce capital costs of nuclear plants, but may not bring them down to the level of conventional plants.

Among the fuel-cycle costs, a large item for reactors using enriched uranium is the cost of fabricating the fuel elements. This is a profitable area for research and development. Increased experience may permit simplification of design and relaxation of tight specifications for fuel elements. As the nuclear industry grows, the effects of mass production should reduce a number of the fuel-cycle costs. Some of these improvements will undoubtedly be incorporated

in existing reactors, so that the average fuel-cycle costs over the life of the plant may be considerably less than the initial costs. The inventory charge for enriched uranium, the costs of U^{235} burnup, heavy water, chemical reprocessing and conversion, and the credit for plutonium are all determined domestically by the AEC at present.

APPENDIX 4

THE SHIPPINGPORT PROJECT

REPORT BY AD HOC ADVISORY COMMITTEE TO EVALUATE THE SHIPPINGPORT PROJECT

(U.S. Atomic Energy Commission, February 15, 1960)

Members of the Ad Hoc Advisory Committee To Evaluate the Shippingport Project

William S. Peterson, general manager and chief engineer, department of water and power, the city of Los Angeles.
Henry D. Smyth, chairman of the university research board, Princeton University.
Eugene P. Wigner, professor of mathematical physics, Princeton University.
Robert E. Wilson, retired chairman of the board, Standard Oil Company of Indiana.
Philip Sporn (Vice Chairman of the Committee), president, American Electric Power Co.
Alfonso Tammaro (Chairman of the Committee), Assistant General Manager for Research and Industrial Development, U.S. Atomic Energy Commission.

The meetings held by the Committee, sources of basic data utilized, and consultations with Government officials and others in pursuance of the Committee's work are described in detail in appendix A.

I. SUMMARY

1. At its first meeting the Committee concluded that the original terms of reference could not be fully complied with in the time available. It, therefore, agreed on certain limitations of these terms as set forth in the section immediately following this summary.

2. The Committee was unable to undertake evaluation of the Shippingport program for more than the immediate future (i.e. the next 5 years or so). A detailed, longer term study is, however, important and the Committee recommends that one should be made.

3. The PWR–2 program under which core–2 will be installed represents significant improvements and advances as compared with PWR core–1 and should yield results of substantial value to the national civilian 10-year power program.

4. We have been assured that planning and developmental work on core–2 with a rating of 150 megawatts has already proceeded so far as to render moot the question of undertaking core–2 with a somewhat lower rating. We feel bound to say, however, that the review that the Committee was able to make did not convince them that the increased costs were warranted by the technical advantages of a rating above the 100 megawatts for which generating equipment is already installed.

5. Given the increased rating of the core to 150 megawatts equivalent—the question of disposing of the excess steam that will be generated as a result is still undecided. Since as much relevant information can be secured at far lower costs by installing a heat sink rather than additional electrical generating and transmission facilities, the Committee urges such a course.

6. In addition to the impressive results of Shippingport to date and the equally impressive plans for the next few years, there is certain other research and developmental work which deserves emphasis both in continued operation of core-1 and in later operation of core-2—again in the near future. This work includes such items as exploring possibilities of operating core-1 at values above 60 megawatts on a carefully planned basis; and the introduction of plutonium into PWR at as early a date as possible.

7. While detailed evaluation of Shipping port costs to date is not attempted, data on them as made available to the Committee indicate that cost estimates for the immediate future are in line with what should be expected of a project of the pioneering nature and proportions of Shippingport.

8. The Committee has also observed differences of approach and philosophy between the Shippingport Project and the rest of the AEC reactor program. We believe that the Shippingport project and the entire civilian power program would be more effective if all were coordinated under the national civilian 10-year power program as fixed by AEC policy.

II. TERMS OF REFERENCE FOR EXECUTION OF ASSIGNMENT

In the letter of the Commission dated January 13, 1960, setting up the Ad Hoc Advisory Committee To Evaluate the Shippingport Project, the terms of reference are stated as follows:

> "It shall be the purpose of the special Ad Hoc Advisory Committee To Evaluate the Shippingport Project to—
>
> "(*a*) Review a report being prepared by the Division of Reactor Development containing an analysis of present and future operation of the Shippingport reactor project and associated costs; and
>
> "(*b*) Advise the Commission as to their views and recommendations on the objectives of the Shippingport project, its contribution to central station nuclear powerplants, and the associated project costs.
>
> "In keeping with the requirements of the Code of Federal Regulations (sec. 7.4 of 10 C.F.R., pt. 7), which sets forth regulations under which advisory boards to the Commission shall operate, Mr. A. Tammaro, Assistant General Manager for Research and Industrial Development, has been appointed as Chairman of the Committee."

At the first meeting of the Committee in Washington on January 22, 1960, the terms of reference were reviewed by the Chairman of the Commitee, Mr. A Tammaro. Mr. Tammaro noted that item (*a*) of the terms of reference referred to a report being prepared by the Division of Reactor Development and, amplifying that item, Mr. Tammaro said that it was originally intended that this report contain conclusions and recommendations of the staff which the Committee would be expected to review. He went on to say, however, that based on past experience it seemed more appropriate now that the Committee prepare its own report with its own recommendations. This modification in terms of reference the Committee accepted.

The Committee also discussed that part of item (*a*) referring to the future operation of the Shippingport reactor project and associated costs of item (*b*) proposing that the Commission be furnished the views and recommendations of the Committee on the objectives of the Shippingport project, its contribution to central station nuclear powerplants, and the associated project costs. The Committee came to the conclusion that within the time allotted to it by the Commission it would be beyond its competence to submit recommendations on the long-term role of the Shippingport project. Such long-term problems, they felt, would require an independent study that might take several months and would require a consultant staff. The Committee therefore decided, with the agreement of its chairman, that it would have to limit itself to the immediate future (roughly the next five years) plans of Shippingport, both PWR–1 and PWR–2. As part of this work the Committee agreed that it could make a brief review of the contributions of Shippingport to date to central station nuclear powerplant development, and the contributions that the proposed further work in the immediate future will make toward that end.

The Committee is also in agreement that it may be highly desirable and extremely helpful to explore in full the terms of reference as set up in the Commission's letter of January 13, 1960, but urges that ample time and funds be made available to a proper group set up for that purpose.

III. BRIEF SUMMARY OF PAST CONTRIBUTIONS

For basic information concerning the Shippingport project, the Committee has relied primarily on the AEC report entitled "Review of the Pressurized Water Reactor (PWR) Program, January 14, 1960, prepared by: Shippingport Evaluation Team Division of Reactor Development." The report was supplied to the Committee at its first meeting on January 22, 1960. However, the Committee also consulted other reports and memoranda including the book "The Shipping-

port Pressurized Water Reactor" prepared for the U.S. Atomic Energy Commission. Other information used is referred to in appendix A.

The Shippingport pressurized water reactor project first went critical on December 1, 1957, began supplying electricity to the Duquesne Light Co. system on December 18, 1957, and on December 23, 1957, the plant turned out 60,000 kilowatts net, operating on three of its steam generating loops. In the 2 years since the end of 1957 many tests have been made to evaluate the design and performance of the parts of the plant and the plant as a whole. The project had, as of the middle of January 1960, operated a total of about 5,800 equivalent full power hours and had generated a total of 388,500,000 kilowatt-hours gross of electric energy. The plant, one of those outstanding characteristics is that its core is of the seed and blanket type, is at present shutdown, being in the process of having its first seed replaced.

Shippingport is the first U.S. nuclear plant in power supply service. From the start, however, the main purpose of the Shippingport project, including the associated research and development work at Bettis, has been to advance the technology of pressurized water reactors and in some respects of all light-water moderated and cooled reactor technology, as such its contributions have over the past 3 years been extensive and indeed impressive.

Without attempting to go into detail, it is worthwhile to catalogue some of the major contributions of Shippingport: in fuels, the advancement of UO_2 and pellet technology; in physics and fuel economics, the development of the seed and blanket concept; in materials, the development of zirconium alloys. Other significant contributions are: in large reactor core design, the development of data on heat transfer both within the fuel elements and from them to water; in mathematical analysis, the development of an extensive coding program involving many aspects of nuclear calculations; in components, the development and the bringing to successful conclusion of a program for the design and construction of large canned motor pumps. All of these constitute in totality an impressive list of research and developmental results and contributions to the pressurized water and the general civilian atomic power program. It is true that not all of these ideas originated with the Shippingport project, but all of them eventually found employment in PWR–1 where they were carried further than was elsewhere the case.

The achievements of Shippingport and its contributions as a prototype plant are in perhaps a different category. In many cases the contributions arose principally from the fact that Shippingport was the first large civilian power reactor. It therefore had the advantages and disadvantages associated with that circumstance. The project developed initial contact with manufacturers and fabricators. It worked out initial problems of safety of equipment with safety code agencies and health authorities. It also worked out health safety problems with such agencies. It developed design and specification standards on welds, valves, and other similar components. It worked out details in connection with the handling of radioactive wastes and their decontamination or general cleaning up when that was possible.

Shippingport was also the first reactor plant to become part of an integrated system of power supply. No difficulties were experienced in this integrated operation; the reactor plant was found well suited and responsive to the needs of a component of energy supply in a power system for either peak or base load operations.

PWR having now had the benefit of 2 years' operation as a prototype and as a core test facility has by no means exhausted its potentialities as an experimental and developmental tool especially in view of its high degree of instrumentation. Some of its greatest usefulness may still be ahead of it.

IV. IMMEDIATE FUTURE PLANS FOR SHIPPINGPORT

During the past year work has been proceeding on the design of the second Shippingport core (PWR–2). Depending upon whether two or three seeds are used for the first core, the second core is planned to be in operation either in April 1962 or in August 1963. The principal objective of the PWR–2 program is the development of a higher performance core in terms of both power density

and lifetime. Some of the figures showing significant advances and improvements of PWR–2 as planned over PWR–1 are as follows:

	PWR–1	PWR–2
Power	68 mwe	150 mwe.
Life (based on 1 blanket and 2 seeds)	12,500 hours	20,000 hours.
Energy	0.85×10^9 kilowatt-hour (at the end of 1961).	3×10^9 kilowatt-hour.
Power density	Seed 75 kilowatt/liter, blanket 25 kilowatt/liter.	Seed 130 kilowatt/liter, blanket 40 kilowatt/liter.
Weight of natural uranium	14 tons	19 tons.
Weight of enriched U^{235} per seed	75 kilograms	290 kilograms.
Total cost of fabrication (1 blanket and 2 seeds).	$16.1 million	$17 million.
Total cost of natural uranium and U^{235}	$3.1 million	$10 million.
Fuel cost in mills per kilowatt-hour	19	6.6.

In addition to those tabulated many other improvements are contemplated for PWR–2. In order to get higher density and keep temperatures within proper limits a new type of fuel element is planned for the blanket consisting of compartmented flat plates containing UO_2 using Zircaloy–4 as cladding. There will be other significant modifications such as a change in geometry of the seed, increased size but reduced number of control rods, increased length of core from 6 to 8 feet, a closure head of new design which will incorporate a single refueling port, addition of a support or intermediate flange to the pressure vessel (a so-called Dutchman), which permits side exit of instrument leads instead of through the top as at present and which will materially reduce the time required for assembly or disassembly of the core, and a modification of the cooling flow pattern to include two passes through the blanket.

This core is planned to have a power capacity which could generate 150 mwe. In order to make it possible to bring about this increase in capacity as a result of a changed core $5 million will have to be expended in primary plant modifications. In addition, if steam-electric generation facilities were to be provided over and above the presently installed 100 mwe., we are informed that an additional expenditure of $15 million in plant and $5 million in transmission facilities would be required. A much less expensive alternative is the installation of a heat sink to dissipate the additional heat generated, at an estimated cost of $4 million.

We have been assured that engineering work on core–2 at the 150-mw. rating, which has been going on steadily during the past year, has already reached such an advanced stage as to render moot the question whether an output lower than 150 mw. might have been preferable. A 6-foot core with a rating of 100 mw. would be less expensive than an 8-foot core with a 150-mw. rating. From the review we have been able to make, we have not been convinced that a 6-foot core at 100 mw. would not achieve the essential objectives of the project. Since this is the unanimous judgment of the Committee, we feel it ought to be reported.

Accepting the conclusion that at the present time the developmental and design work on core–2 at 150 mw. is so far along that no other course than the continuance of the work on the basis of 150 mw. equivalent output with an 8-foot length of core ought to be considered, there remains one major question. If the maximum in the way of information is to be obtained it would be necessary to produce the equivalent of 150 mw.—but without necessarily converting it into electrical energy.

The major question still open is the conversion of the steam produced by the core into electrical energy. The facilities presently available for steam-electric generation and absorption within the transmission facilities of Duquesne are adequate for a full 100 mw., and at times possibly up to 106 mw. The information sought and which can be obtained from the 150-mw. reactor is virtually independent of how the steam produced by the reactor is disposed of. Duquesne Light Co. has estimated that "heat sink" facilities for that purpose can be provided by an investment of no more than $4 million, thus saving a total of around $16 million represented by the cost of additional steam-electric gen-

erating facilities and additional transmission facilities, even after allowing for the value of the additional electricity obtained.

The Committee has disclosed this problem with the staff of Bettis Field, with the Duquesne Light Co., and with Admiral Rickover. It has also very carefully considered the judgment of the Shippingport evaluation team of the Division of Reactor Development of the AEC as expressed in its report of January 14, 1960, referred to above. The judgment of the evaluation team that "Use of a heat sink for power dissipation meets all of the requirements for proving out the higher power capabilities and thus the developmental objectives of PWR–2" (report, p. 43) is one that the Committee strongly agrees with.

The Committee is not unmindful that if steam energy created by PWR–2 is thus dissipated to the atmosphere by the heat sink, the operation would have the appearance of a wasteful use of a natural resource, i.e., atomic fuel. We must emphasize, however, that it cannot in fact be regarded as wasteful to dissipate energy in this way when no economical means exist to use it and where the production of the steam is the necessary result of a desirable research and development project. Shippingport has already served its purpose as a demonstration nuclear electric powerplant; insofar as any further purpose might be served by Shippingport operating as a demonstration plant generating electric power at a rating of 150 megawatt this purpose will have been performed by the time Shippingport generation could come into being by at least two other plants which could be considered as the sons or daughters of Shippingport and which will be operating at that time at or above 150-megawatt rating.

Taking, therefore, the situation overall, the Committee has concluded that the optimum program in the overall research and developmental project of developing Shippingport (PWR–2) to 150-megawatt rating is to omit the unnecessary expenditures which would inevitably be involved in adding the additional electrical capacity, but rather to utilize the less costly heat sink approach.

Other recommendations

The Committee is of the opinion that among the many clearly indicated objectives of PWR–2 and core 2, including larger power, longer life, higher power density, experience with the wafer compartmented type plate UO_2 element, experience with the longer plate type element, all of which should yield to effective exploitation in the civilian power program, there remain a number of other items that deserve emphasis in any efforts to optimize the usefulness of PWR–1 and PWR–2. Among these are the following:

(*a*) When the reactor is reactivated with seed–2, but with the present blanket intact except for fuel elements renewed for test purposes, it is contemplated to bring its capacity up again to 60 mwe. The Committee has persistently explored the question of going beyond and gradually raising the level of power—still with core–1—to values above 60 megawatt on a carefully planned exploratory basis. The Committee takes note of the highly desirable aim to explore core–1 through seed–2 and possibly seed–3 from the standpoint of longer core life. But there is coming in, after all, increasing information on core life from other power reactors. Provided the attempt to raise core–1 rating above 60 megawatt is done with great care the Committee believes it ought to be tried—certainly by the time seed–3 is reached. Such action offers the possibility of finding greater limits for rating of existing designs.

(*b*) The distinguishing characteristic of PWR is the fact that it is the only seed and blanket concept that has been implemented in the U.S. civilian water reactor program so far. It would appear highly desirable that this be fully developed and that core–1 blanket life should be extended as far as possible. We do not believe, however, that this is incompatible with the tests recommended in (*a*) above.

(*c*) From our discussions with the staff of the Assistant Director for Naval Reactors, Division of Reactor Development, and with the Bettis staff we understand that, in order to test fully the lifetime of the fuel elements in the blanket, a third seed will be employed in core-1 if possible. Furthermore, since the seed and blanket concept also carries with it the highly favorable concomitant of the potential maximizing of the use of plutonium, it would appear that plutonium ought to be introduced into PR at as early a date as possible, and some plutonium ought to be introduced into seed-3, core-1.

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(*d*) In view of the promise of the seed and blanket concept it is the judgment of the Committee that the economic advantages of this concept from the standpoint of fuel should be thoroughly explored by analytical and computer methods, and this should be undertaken at the earliest feasible date. Representatives of the Naval Reactors Group recommend using nuclear fuel in a form that involves the minimum utilization of fossil fuel for its preparation. On the other hand, the expenditure of energy to refine fuel, whether it be coal, oil, or uranium, has often proved economically sound and is not inconsistent with the demands of conservation. The relative merits of these two views can be illuminated by the suggested analytical studies.

(*e*) Finally, one of the methods that the Committee strongly urges to make the Shippingport project more useful to the overall civilian power program is greater attempt to make information developed by the project available as expeditiously as possible.

V. BRIEF EXAMINATION OF PAST AND FUTURE COSTS

In order to get a view of Shippingport in proper perspective it is desirable to take a brief look at the costs to date. This is not done with a view of evaluating costs in terms of contributions to date and weighing one against the other. As already pointed out, this would involve a much more detailed analysis than it was possible for this Committee to make within the time limits prescribed for it. But in considering immediate future it is illuminating to view what has happened to date.

As of October 31, 1959, the following represents a condensed table of costs covering the period 1954–59:

	Millions
Construction cost (includes $12.7 million for 1st blanket and seed)	$75.2
R. & D	80.6
Fuel fabrication (seed-2 and core-2; excludes fabrication of 1st core)	4.0
Test operations	3.0
Total	162.8
Revenue (from Duquesne for steam	2.8
Net cost (excludes nuclear material)	160.0

The tabulation includes the total costs of $20.2 million spent by Duquesne for the turbine generator plant, including transmission facilities, and the $5 million Duquesne participation in the cost of AEC's nuclear plant.

Currently costs incurred for Shippingport are at the rate of approximately $18 million per year. The total presently estimated cost to be incurred in fiscal years 1960–65 is given in the following table:

	Millions
R. & D	$40.4–$43.4
Fuel fabrication	21.5–21.5
Test operations	10.4–11.9
Total	72.3–76.8
Revenue (from Duquesne for steam)	9.7–9.7
Net cost	62.6–67.1
Nuclear plant modifications for 150 mw	5.0–5.0
Heat sink for 150 mw	4.0–4.0
Total	71.6–76.1

This is an average of close to $12.5 million a year for each of the 6 years 1960–65. As the tabulation shows it is based on using a heat sink; it does not take into account any additional generator and transmission facilities.

The continuing operation of Shippingport; Operation of PWR–1; the problem of the installation, operation, and the significance of PWR–2; and the expenditures that the latter will involve, are tied up with the question of what has already been spent and what additional expenditures will be involved to make

the most effective use of PWR–1 and PWR–2. From that standpoint the program contemplated by PWR–2 and the operating program projected for perhaps the next 5 years seems to be roughly in line with prospective benefits. It is when one reaches out beyond that period that a more thorough study and evaluation are called for particularly if complete coordination between the work carried at Shippingport and the rest of the work looking toward the implementation of the national civilian nuclear power program established as Commission policy is to be obtained.

VI. GENERAL OBSERVATIONS

The Committee having examined the work and the experience gathered at Shippingport is impressed with the significant contributions that Shippingport has made and will further make toward the objectives of the national civilian nuclear power program. At the same time the Committee was impressed by the necessary differences of approach in design of equipment and plant for civilian power, on the one hand, and for naval requirements, on the other hand. For this and other reasons it is the judgment of the Committee that there is room for closer integration and coordination of the Shippingport program with the overall program of the Commission and specifically with the much more clearly stated objectives of the national civilian nuclear power program which have the status of established Commission policy.

Respectfully submitted.

W. S. PETERSON.
H. D. SMYTH.
E. P. WIGNER.
R. E. WILSON.
P. SPORN, *Vice Chairman.*
A. TAMMARO, *Chairman.*

APPENDIX A

The Committee held a series of six meetings as follows.

First meeting: January 22, 1960, Washington, D.C.
Second meeting: January 23, 1960, Washington, D.C.
Third meeting: (9 a.m.) January 29, 1960, Bettis Laboratory, Pittsburgh, Pa.
Fourth meeting: (8 p.m.) January 29, 1960, Duquesne Club, Pittsburgh, Pa.
Fifth meeting: January 30, 1960, Shippingport, Pa.
Sixth meeting: February 6, 1960, New York, N.Y.

In the course of these meetings the Committee had the benefit of consulation with numerous Government officials and others concerned with Shippingport. The Committee also had the benefit of its field examination of the facilities and work at Shippingport and Bettis. We wish especially to acknowledge the assistance of Admiral Rickover, Mr. Mandil, Dr. Radkowsky, and other members of the Naval Reactors Group; Mr. Cresap, Mr. Simpson, Dr. Shoupp, and others of Westinghouse Electric Corp.; Mr. Weaver, Mr. Ross, Mr. Hamilton, Dr. Lustman, Mr. Bayard, and others associated with the Bettis Labortory staff; Mr. Fleger, Mr. Gray, and others of Duquesne Light Co.; Mr. Webster and Mr. Coe of the Yankee Atomic Project; and, of course, Dr. Pittman, Mr. Staebler, and Mr. Voigt of the AEC Reactors Division; and Mr. Ewing of the Secretariat office.

Other important sources of information were—

AEC report "Review of the Pressurized Water Reactor (PWR) Program" prepared by: Shippingport Evaluation Team, Division of Reactor Development, January 14, 1960.

Report "Shippingport PWR Project" prepared by Naval Reactors Branch of Division of Reactor Development, January 1960.

The book "Shippingport Pressurized Water Reactor" presented at the Second International Conference on the Peaceful Uses of Atomic Energy, Geneva 1958.

Report "Civilian Nuclear Power" prepared by the Ad Hoc Advisory Committee on Reactor Policies and Programs, January 2, 1959.

Report of Duquesne Light Co. on Expansion of Shippingport, dated July 31, 1959.

EXCERPTS FROM REVIEW OF THE PRESSURIZED WATER REACTOR (PWR) PROGRAM, JANUARY 14, 1960

AEC Shippingport Evaluation Team, Established by the Director, Division of Reactor Development

U. M. Staebler, *Chairman.*
W. C. Bartels.
D. L. Couchman.
Edward J. Kirkham.
I. H. Mandil.
Harold E. Vann.
W. R. Voight.
M. J. Whitman.

I. SUMMARY

This report is a technical review of the pressurized water reactor (PWR) program. It reviews the technological accomplishments which have resulted to date from this program, the technical advances which are expected to be achieved in the next 3 to 5 years, the economic promise of these developments, the costs associated with the program, and the technological relationship of this project to the overall civilian power reactor program.

The PWR project was authorized in July 1953, and construction started at Shippingport in March 1955. The plant achieved initial criticality on December 2, 1957, and was operating at full power 3 weeks later. The plant has now been in operation for approximately 2 years, during which time many tests have been made to evaluate its design and its performance. The plant is at present in the process of having its first seed replaced; so far, the plant has operated a total of about 5,800 equivalent full power hours and has generated a total of 388,500,000 kilowatt-hours gross of electricity.

The PWR project from the outset has been directed toward advancing the basic technology of indirect cycle water reactors through the design, development, building, testing, and operation of a large power reactor suitable for central station operation. Design objectives included such things as long core life, reliable fuel elements, significant amounts of power from natural uranium, extensive core and plant instrumentation, permissible operation of the plant with failed elements, means of readily detecting failed fuel elements and the ready removal of such elements through the pressure vessel head. These objectives were established early in the project and appear to have been successfully accomplished based upon experience to date. At all times, safety of the reactor plant has been an overriding consideration.

The PWR Project has been and is continuing to be an important tool for making significant advances in the technology of pressurized water reactors.

The philosophy of planning and direction of the PWR project may be characterized as one emphasizing depth of technology development, safety and reliability in plant operation, and strong Government controls in line with Government responsibility for the timely completion and successful operation of the plant. The mission of the project continues to be one of developing and testing new technology which should lead to lower costs rather than exploiting the economic potential of any demonstrated technology.

As a complete powerplant, the PWR has demonstrated that it can be easily integrated into a large utility's electrical power system. The reactor has demonstrated its ability to produce its rated steady power and to respond to load transients with complete safety and without appreciable operating problems. The operating personnel consider that the plant is suitable for operation as a base load station or a peak load station or as combination of both, and that its flexibility is superior to that of a coal-fired plant.

The contributions resulting from the design, development, construction, and operation of the Shippingport plant and its first core, can be divided into four main areas. These are in the fields of reactor physics, fuel technology, reactor design, and powerplant engineering.

The seed and blanket concept has demonstrated (*a*) that it is feasible in the light water system to obtain large amounts of power from a blanket of natural uranium by using a seed, which is a small highly enriched core, as the driving element; (*b*) that the inventory of enriched fuel required can be greatly reduced; (*c*) that it is possible to control the entire reactor core by using only a few control rods which are located in the relatively small seed volume; and (*d*) that a seed and blanket core possesses a favorable dynamic response and large negative temperature coefficient.

In the field of fuel technology, the PWR project has been largely responsible for the development of uranium oxide (UO_2) as a fuel material for large power reactors. In view of its widespread application, this has been and is continuing to be a major contribution in the field of reactor fuel materials. Extensive testing, both in pile and out of pile, was performed to permit the use of bulk UO_2 in rod geometry. Through continuing in-pile tests and the operation of the PWR core-1, the limitations that may exist in the use of this fuel material will be determined. There are a large number of variables involved, such as fuel temperatures, heat fluxes, fuel element shapes, and fuel-to-clad clearance, which can vitally affect the behavior of this material under irradiation. In PWR–1, the UO_2 is in pellett form and is contained in zirconium alloy (zircaloy 2) rods.

Important accomplishments in the area of reactor design included (*a*) the determination of heat transfer and pressure drop correlations for both rod and plate type fuel elements in high temperature and high pressure water under numerous conditions, (*b*) the development and incorporation of the in-core instrumentation to determine the thermal and hydraulic performance of the core throughout life, and to detect and locate any failed UO_2 fuel elements, (*c*) the development of a mechanical core arrangement such that any failed element or malfunctioning control rod could be replaced without removing the large pressure vessel head, and (*d*) the design of a pressure vessel and head which were the largest built at the time for application in high pressure and temperature water.

The PWR project has been instrumental in establishing suppliers for the manufacture of primary coolant components of a size, capacity, and complexity much greater than was available at the time the project was initiated. As a result of this pioneering work, industrial suppliers are now available and have actually supplied primary nuclear components for water-cooled reactors of sizes and capacity still greater than those that were built for the Shippingport reactor plant.

A planned program of performance testing has been followed as part of plant operation. This test program has produced substantial data which can be used in future designs of other nuclear powerplants. Verification of reactor physics calculational models and heat transfer and hydraulic calculations, demonstration of plant stability, demonstration of the response to load changes, component reliability, long-term effects such as corrosion buildup and radiation level buildup—all have been measured at Shippingport. In addition to technical data acquired, experience has been gained in developing the technical organization required by an operating utility to handle maintenance, repair, and refueling operations.

Much needed information on the long-term behavior of major plant components will be obtained from the continued operation of the Shippingport plant; thus, a more realistic basis for judging the adequacy of, or need for, some of the design specifications will be provided. Such additional operating experience will pilot long-term performance to be expected from similar components in plants now under construction or in early stages of operation.

The replacement seed which is now being installed in PWR–1 aims toward extending core life, including demonstration of the use of burnable poisons.

Work is proceeding toward a second Shippingport core (PWR–2). Depending upon whether two or three seeds are used with the first core, the second core would be in operation in April 1962 or August 1963.

The principal objective of the PWR–2 program is the development of a very high performance core in terms of both power density and lifetime. PWR–2 will have about 5½ times the design energy output and about 3 times the energy output presently estimated achievable in PWR–1. The power density of PWR–2 is expected to be about twice that achieved with PWR–1. Such performance should lead to reductions in both fuel cycle costs and capital costs.

Fuel planned for PWR–2 consists of compartmented flat plates containing UO_2 wafers using Zircaloy-4 as cladding. The fuel elements also will incorporate self-shielded burnable poison and zones of different uranium concentration to reduce power peaking. PWR–2 is more than just a change in fuel shape and composition. It includes other significant plant modifications, such as change in geometry of seed, increased size but reduced number of control rods, increased length of core from 6 to 8 feet, a closure head of new design which incorporates a single refueling port, addition of a support flange to the pressure vessel which permits side exit of instrument leads, and modification of coolant flow pattern to include two passes through the blanket. Major development efforts are planned on reactor physics, computer codes, thermal design, and

mechanical design (including core instrumentation) to meet the reactivity lifetime, power distribution, and heat transfer objectives of PWR–2.

PWR–2 is planned to have a power capacity which could generate 150 mwe. A core of this power rating will provide information which is more directly applicable to large central station nuclear plants. The basis for this choice of power rating is described in section IV of this report.

The work planned for continuation of the PWR project represents a development program for water moderated and cooled power reactors using the Shippingport reactor as the ultimate test facility. It is not possible to explore in a single reactor all of the design variations or process improvements which have promise of leading to economically competitive nuclear power. The water reactor development program planned around the Shippingport reactor is oriented, in particular, toward seed and blanket cores of flat plate geometry with no net steam generation out of the reactor core but some bulk boiling in hottest channels. The work planned is largely complementary to other work being carried out toward the objective of reducing the cost of power from water moderated and cooled reactor systems. Past experience has indicated that information developed in the program will be promptly and effectively reported by means of periodic and topical reports and special technical interim reports.

Construction costs on the Shippingport project, including the cost of the first seed and blanket core, total $75 million. Other expenditures through October 1959 include $81 million in research and development, $4 million in fuel fabrication (seed–2, spare subassemblies, and start of PWR core–2) and $3 million in test operations. This total of $163 million includes approximately $139 million of Commission funds. Plant operation, fuel fabrication, and associated research and development carried out under the project is expected to cost the Commission approximately $18.5 million in the current fiscal year (fiscal year 1960). While it is very difficult to estimate future costs, a figure of the order of $55 to $60 million appears to be required for continued research and development, fuel fabrication, and test operations to cover continuation of the program through fiscal year 1965. This period would include of the order of 1½ to 3 years of operation with the second core depending upon whether or not a third seed is used with the first core. It is estimated that plant modifications to accommodate the second core, as now planned, would require additional amounts of approximately $5 million for the reactor portion (authorized in fiscal year 1960) and $4 million for additional heat removal capacity in the form of a heat sink or $16.4 million if additional turbogenerator capacity is added.

The technical advances expected from the PWR development program should make it possible to achieve fuel cycle costs that are consistent with the Commission's stated objective of obtaining competitive nuclear power in high cost areas (35 cents per 10^6 B.t.u.) by 1968. The above statement is based on current Commission practices and assumptions used in calculating fuel cycle cost and in the expectation of reduced fabrication cost, for cores of the type planned for PWR–2.

Contributions of the PWR project are not limited to contributions of technology. Experience with the cooperative arrangement between the Government and the Duquesne Light Co. is of interest and value in planning other cooperative projects. Flexibility for the Government to redirect program efforts of the technical development support group and of the plant operator, without contract renegotiation, has contributed to expediting progress in directions chosen.

* * * * * * *

IV. FUTURE PLANS FOR THE SHIPPINGPORT PWR PROGRAM

The future plans and objectives connected with the Shippingport Atomic Power Station project can be divided into two main parts. Those connected with the continued operation of PWR core–1 with replacement seeds and those connected with PWR core–2.

1. Future plans and objectives connected with PWR core–1

The Shippingport reactor is at present in the process of having its first seed replaced. Advantage is being taken of this refueling period to inspect and test parts of the core, including some of the blanket UO_2 fuel elements, zirconium structures, and hafnium control rods. The blanket of the core will be left in place with the exception of those fuel elements which are removed for test purposes. The average burnup of this blanket is at present 1990 MWD/T of UO_2, which is the highest value achieved to date on a large amount of UO_2 in any operating

power reactor. It is still a long way, however, from the 10,000 MWD/T, or more, average burnup being assumed in the design and economic calculations of many civilian water-cooled power reactors. During plant operation, blanket exposure increases at a rate of 3,000 MD per ton for each year of continuous full power operation. Because of the importance of determining the life potential of the UO_2 rod-type elements, it is planned that a third seed will be installed after the depletion of the second seed in the PWR core–1; provided, however, that tests and examination show the blanket to be still in good condition at the end of seed–2 operation. The operation of core–1 with additional seeds will provide data on the following important factors:

(*a*) Irradiation limitations on a large core loading of UO_2 fuel rod elements.

(*b*) Physics characteristics and thermal performance of seed and blanket cores as a function of increasing fuel depletion.

(*c*) Long-term reliability of the reactor core structure, primary coolant components, and control systems.

In addition, the operation of the PWR plant provides a facility for the training of personnel for central station nuclear reactor plants.

2. Future plans and objectives connected with PWR core–2

Results of the PWR program have made possible the development of a higher power and longer life core (PWR–2) for installation in the Shippingport pressure vessel. This step is expected to result in major reductions in fuel cycle and capital costs per unit of power equipment.

The major differences between PWR–2 and PWR–1 are summarized below:

(*a*) Core power of PWR–2 is 525 mwt (150 mwe) with four coolant loops in operation as compared with 231 mwt (67 mwe) for PWR–1 with three coolant loops in operation.

(*b*) Core–2 will have plate type UO_2 fuel elements in both the seed and blanket as compared with metallic plate elements in the seed and rod type UO_2 elements in the blanket of core–1.

(*c*) Core–2 will have a different geometry of seed and blanket arrangement and will require only 20 control rods as compared with 32 for core–1.

(*d*) Core–2 is designed for 20,000 equivalent full power hours in the blanket with 10,000 equivalent full power hours for the first seed as compared with 8,000 and 3,000 equivalent full power hours, for the blanket and seed, respectively, of core–1.

(*5*) Core-2 will have two pass coolant flow in the blanket as compared with a single pass in core-1.

(*6*) Core-2 will have an 8-foot core height as compared with 6-feet for core–1.

(*5*) Core–2 will have two pass coolant flow in the blanket as compared

(*7*) The pressure vessel head for core–2 will utilize a new design that will have a single refueling port in the head as compared with 10 ports in the core–1 design.

(*8*) PWR–2 pressure vessel will have a flange between the vessel and the head to accommodate instrument leads from the core. Because of this arrangement, the core instruments will not interfere with refueling operations as is the case in PWR–1.

(*9*) The core will incorporate remote manually adjustable floworifices in the fuel assemblies for changing distribution in the core to take care of power shifts which may occur during lifetime.

(*10*) The average power density of core–2 is expected to be about twice that of core–1. (Increase from 75 to about 130 kilowatt per liter of the seed and from 25 to about 40 kilowatt per liter of the blanket.)

Figure 1 shows a comparison of PWR–1 and PWR–2.

Figure 2 shows a cross section of the two cores.

Figure 3 shows a more detailed picture of PWR–2.

3. Choice of core size

In establishing the developmental objectives for PWR core–2, consideration was given as to whether this core should be designed for 100 megawatt gross electrical or 150 megawatt gross electrical power output. The latter output represented about the largest core size which would still fit in the Shippingport pressure vessel. The largest practical core size that could be put into the Shippingport pressure vessel was selected for PWR–2 because it would provide information of more nearly direct applicability to the design and evaluation of large central station

nuclear powerplants of this type. The seed and blanket type core with UO_2 fuel makes it particularly important to maintain the radial dimension of the core if one is to obtain a large amount of power from the natural uranium blanket. An increase in length of the core provides information on thermal, hydraulic, and physics characteristics of longer fuel channels which is of general interest for design of water-cooled power reactors. A smaller core would provide a demonstration of the feasibility of higher power density but the larger core would provide improved information on the following items as well:

(*a*) Performance of the seed and blanket core concept, including its negative temperature coefficient in large power reactors.

(*b*) The axial and radial stability of the core under full power operation as a function of core exposure. Since oscillation is expected to be a problem in any large core and may be aggravated by uneven fuel depletion, it will be of great importance to determine if any incipient oscillations can be suppressed with as much ease as was the case for PWR–1.

(*c*) Reactor control in a large core. Reactor control problems are considerably more severe as the power density, core volume, and core lifetime are increased.

(*d*) Means of maintaining a satisfactory power distribution over an extended lifetime for a high power core. Due to uneven burnup, it becomes significantly more difficult to maintain good power distribution in a core of high power rating over a long lifetime since nonuniform burnup may produce heavy concentrations of fuel in particular areas.

(*e*) Fuel removal procedures and equipment which are more complex in a large size reactor core.

(*f*) The hydraulic and thermodynamic properties of the longer flow sections.

In order to dissipate the higher power output of PWR–2, it will be necessary to either expand the electrical generating portion of the Shippingport plant from 100 megawatts to 150 megawatts or provide a suitable heat sink. The Duquesne Light Co. has submitted to the Commission proposals for either one of these possibilities and from an economical standpoint, the heat sink proposal is more attractive. Use of a heat sink for power dissipation meets all of the requirements for proving out the higher power capabilities and thus the developmental objectives of PWR–2.

Some of the more important developments that are being performed in connection with PWR–2 can be summarized as follows:

(*a*) Plate type fuel elements of UO_2 are under development for both the seed and blanket portions of the core. This type of fuel element will be suitable for operation at high heat fluxes and to high burnups and yet will maintain a relatively low central temperature (1,200° to 1,500° F.). In addition, these plate type elements provide an easy way of compartmenting the fuel into small volumes to limit the consequences of cladding failure. This fuel element technology is considered achievable as a result of the data obtained from basic metallurgical work, development of oxide plate fabrication and bonding methods, and inpile fuel irradiation of plate elements which have reached values of approximately 60,000 MWD/T of UO_2.

(*b*) Methods are under development for using lumped burnable poisons such as boron-carbide in specific locations of the core with the objective of reducing the peak-to-average power distribution, increasing seed life, and reducing the amount of mechanical control that is required.

(*c*) An improved zirconium cladding material, Zircaloy–4, which is less susceptible to hydrogen pickup and therefore to embrittlement, will be used in the fabrication of PWR–2 fuel elements. It is anticipated that Zircaloy–4 will be a much more suitable cladding material for long life cores than Zircaloy–2.

(*d*) Digital computer codes adequate for analysis of a large multiregion power reactor over the full power life of the core will be developed. The largest digital computer will be used to determine in three dimensions, for heterogeneous lattices, the local power density as a means of locating any serious hot spots and power gradients, so that they can be avoided by adjustment of local fuel and burnable poison concentrations.

(*e*) Improved incore instrumentation will be developed to determine with better accuracy the nuclear and thermal performance of the core and measure asymmetric power distributions that may take place.

(*f*) Heat transfer correlations will be developed for long plate type cores under both steady state and transient conditions to take full advantage of the high power density potential of UO_2 plate type fuel elements.

(*g*) The core will also utilize a two-pass flow arrangement in the blanket with an adjustable flow orifice in each individual fuel assembly to accommodate power shifts that occur with lifetime. The change in orificing is performed during seed refueling by inserting a special tool in the reactor through the refueling port, and does not require removal of the individual fuel assemblies from the core.

Planned schedule

Current best estimates of the Shippingport schedule for core insertion and removal are given below:

TABLE 1.—*Shippingport core schedule*

A. ASSUMING BLANKET PERFORMANCE IS ADEQUATE FOR INSERTION OF SEED–3

Seed 2–Start operation	April	1960.
Seed 2–Depleted	September	1961.
Seed 3–Start operation	December	1961.
Seed 3–Depleted	January	1963.
Core 2–Start installation	March	1963.
Core 2–Start operation	August	1963.

B. ASSUMING BLANKET PERFORMANCE IS NOT ADEQUATE FOR INSERTION OF SEED–3

Seed 2–Start operation	April	1960.
Seed 2–Depleted	September	1961.
Core 2–Start installation	November	1961.
Core 2–Start operation	April	1962.

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APPENDIX 5

AMERICAN PUBLIC POWER ASSOCIATION,
December 16, 1959.

Senator CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Washington, D.C.

DEAR SENATOR ANDERSON: Members of this association's atomic energy committee had the opportunity on December 9 to be taken on a very thorough tour through the Atomic Energy Commission's Shippingport plant and to witness the fuel element removal operation now going forward. Our group was greatly impressed by the unique value of Shippingport as a power reactor development laboratory, not only because it is the only large operating power reactor but because it is an extensively instrumented facility and operated for the principal purpose of producing needed technical data. As on previous visits, I was struck by the importance of this facility to the atomic power program and thought I would take the liberty of passing on my impressions to you.

Enclosed is a copy of the latest issue of our Atomic Power Newsletter which includes a summary article on our PWR visit.

I am aware of the fact that there are divergent views as to the value of the Shippingport facility, but my own impression is that it is certainly paying off in the technical data which it is producing and doubtless will continue to provide.

At a matter of fact, it seems to me that Shippingport illustrates a primary need of the atomic power development program. I may be mistaken, but it is my understanding that the privately financed power reactors which are being built are not as heavily instrumented as is the PWR nor will they be operated for the primary purpose of producing new technical information. Equally important, they are not backed up by large development laboratories like Bettis. These plants no doubt, will contribute to the advancement of the technology but I wonder if they can be regarded as substitutes for the type of facility exemplified by the PWR. It seems most probable that we would go ahead farther and

faster in technological development and in gaining an understanding of what really happens in a reactor under various operating conditions if we had more facilities of this character.

As you know, this association consistently has advocated a stronger atomic power development program and, as part of such an effort, some additional Federal plants. We have urged the latter not in the interests simply of creating Federal power capacity but with the thought that such additional plants should be truly developmental facilities and with the conviction that the private utilities cannot afford to build and operate such facilities. They can hardly be expected to spend more on instrumentation and on experimental operations than required for their needs as a utility.

The "second round" approach seems consistent with the construction and operation of demonstration or developmental facilities of the type needed, since the Government finances and owns the reactor, and it may be that fuller advantage could be taken of this opportunity on the second round projects. However, there is a substantial body of opinion that a need also exists for larger plants than are likely to be feasible for municipals or cooperatives under second round arrangements. For example, John Simpson, formerly director of the Bettis Laboratory, testified before your committee last February that there are types of information attainable from the operation of a large reactor that are not attainable from a small one.

Consequently, in addition to the small second-round-type projects and to the projects being built by the privately owned utilities, it has seemed to us that several sizable developmental facilities like Shippingport would be most valuable. As you know, we repeatedly have suggested that these be built at AEC sites and the byproduct power utilized by AEC. The small gas-cooled project now underway at Oak Ridge, thanks largely to your efforts and others on the Joint Committee, is an example of such an arrangement.

The Shippingport visit strengthened another impression I have had, and that is that a large number of assumptions and uncertainties lie submerged beneath the numerous nuclear power cost estimates being published. These uncertainties usually are glossed over by those making the estimates and the impression is given that the cost figures have considerable validity. I was particularly surprised when the AEC Director of Reactor Development recently announced the conclusions of several nuclear power economic studies and stated estimated cost figures down to the nearest one-hundredth of a mill per kilowatt-hour. I don't think there is much justification for pretending that at this stage costs can be estimated with such precision and the briefing at Shippingport supported this belief.

It seems to me that, to attain the nuclear power costs estimated for various types of reactors in the recent AEC studies, a much more considerable effort will be required than has yet to be proposed by the Commission, and I doubt if they will be attained by building only reactors designed and operated with the conservatism necessary for utility-type plants. More PWR-type projects seem required, and no one except the Federal Government is likely to build these. Furthermore, AEC is the only organization with the large laboratories required for backup.

I know that these considerations have been obvious to you and some other members of the Joint Committee in the past, and I hope that during the coming session of Congress you will persist in your efforts to strengthen the U.S. program for the development of economic nuclear power.

Sincerely,

JAMES L. GRAHL.

ALBUQUERQUE, N. MEX., *December 23, 1959.*

Mr. JAMES L. GRAHL,
Director, Atomic Energy Service,
American Public Power Association,
Washington, D.C.

DEAR MR. GRAHL: Thank you very much for your letter of December 16 dealing with the tour which representatives of the American Public Power Association made on December 9 at the Shippingport plant.

I appreciate very much the suggestions you have made about the valuation of the Shippingport plant. I have recently been urging that some such valuations be made because I am a little tired of hearing people announce the cost

of Government-developed power at Shippingport. A vast amount of money being spent at Shippingport is for research, in my opinion, and the amount of money that the Government is using to subsidize the development of steam which is sold to Duquesne Power & Light Co., is, I believe, reasonably small. I would, of course, like to see the exact amount computed so that we would have some idea of what power is actually costing at Shippingport, but I think any special effort would need to take into consideration the things you mention in your letter. You point out that this is an extensively instrumented facility and operated for the principal purpose of producing needed technical data. This is a point that I find frequently overlooked. Shippingport is valuable because it does produce technical data and does afford us a proving ground for various ideas. I would not want it otherwise and I am sure that the $20 million that may be spent annually at Shippingport is of value to the whole utility industry in direct proportion to the amount of energy developed by conventional plants. In other words, five-sixths of the benefits goes to the private utility companies and they should be rejoicing at the work at Shippingport instead of being occasionally critical.

I am returning your letter to Mr. Ramey because I want it in the files of the joint committee, but I appreciate very much the time you have taken to send it to me.

Sincerely yours,

CLINTON P. ANDERSON.

Exclusive Report

APPA ATOMIC POWER NEWSLETTER

APPA ATOMIC ENERGY SERVICE

AMERICAN PUBLIC POWER ASSOCIATION,
Washington, D.C., December 15, 1959.

APPA REPRESENTATIVES MAKE INFORMATIVE TOUR OF SHIPPINGPORT

Seven members of the APPA Atomic Energy Committee spent a day last week at the Atomic Energy Commission's Shippingport atomic power reactor—the 60,000-kilowatt (electric) PWR—and observed the work now underway preparatory to the removal of spent fuel from the reactor. It was the committee's third visit to the pressurized water reactor. The group found that there are more difficulties involved and more to be learned about power reactor fuel removal than current articles on atomic power generally imply.

Several months to remove fuel.—The APPA group received an excellent briefing on the fuel removal process from the AEC officials in charge of the Shippingport reactor and spent several hours on a trip through the plant, including the containment vessels housing two of the four main coolant-steam generator loops and auxiliary equipment.

Mr. Mark Forssel, Chief of AEC's Shippingport office, said that Duquesne Light Co.—which owns the site and turbine-generator and operates the entire plant for AEC under contract—shut down the plant several weeks ago to start work on the fuel removal process, that it would be another 2 weeks or so before the first fuel element is removed from the reactor vessel, and that removing and replacing the spent fuel probably will require 4 to 5 months to complete.

Plant design and utility inexperience prolong operation.—However, Mr. Forssel and Comdr. E. E. Kintner, Deputy Chief of AEC's Pittsburgh area office, emphasized that the 4- to 5-month requirement should not be regarded as representative for power reactors generally. Fuel changing at Shippingport is more difficult because of extensive instrument installations in the core and because the core was designed prior to any experience with changing fuel in a large pressurized reactor. In addition, the AEC officials pointed out, this is the first attempt to change fuel in a large power reactor and also the first experience for Duquesne Light Co. personnel in planning and executing the complex fuel removal process. AEC experts are supervising only to the extent necessary to assure the safety of personnel and the reactor.

One month for average plant.—For a regular power reactor in the Shippingport size range (60,000 to 150,000 kilowatts), the AEC officials estimated that about 1 month would be required for removal and replacement of the reactor fuel charge once the utility learns the process, because of less complex core instrumentation and because the Shippingport experience is leading to core assemblies designed for easier removal and to improved removal procedures.

(For most power reactors, a core is expected to last 2 years or longer.)

Most of core to remain.—Only a portion of the PWR core is being removed. The core consists of a seed—a hollow square of 32 fuel assemblies containing almost pure uranium 235, and a blanket located inside and outside the seed consisting of 113 assemblies containing natural uranium. Only the seed is to be replaced, as the blanket has an "indefinite" life, limited only by the physical integrity of the fuel elements.

New core under design.—The Shippingport seed elements had a design rating of 3,000 full power hours but actually produced over 5,800 full power hours. They will be replaced by improved elements of the same type. Later, the PWR will receive a complete new core which Westinghouse, AEC's research and development contractor for Shippingport, is designing. It will be only slightly larger than the present core but is expected to produce five times the energy—2½ times the power level (150,000 kilowat electric) and twice the life—of the present core.

PWR a development facility.—Shippingport's unique value as a power reactor development laboratory was emphasized by the AEC representatives. Since reaching full power in December 1957, it has been the only large power reactor in the United States and so the only facility in which certain types of information could be developed. The core blanket of uranium oxide elements, for example, has provided the only opportunity for statistically significant tests on the performance of uranium oxide fuel, now the favored fuel for most reactors under design in the United States.

Reactor automatically follows load.—The PWR experience has been encouraging. In designing the reactor system, the failure of as many as 1,000 of the 100,000 natural uranium oxide elements was anticipated. To date, tests indicate that no more than one or two have failed, and these have resulted in extremely slight radioactive contamination of the water in the primary coolant loops. None of the enriched fuel elements failed.

As a power facility, the PWR has proved to be extremely safe and reliable the APPA group was informed and far easier to operate and much more responsive to load swings than a conventional plant. Two of the large "canned rotor" pumps on the primary coolant system have had to be replaced, the group was told, there have been some heat exchanger difficulties, and the moisture separator on the turbine is undergoing extensive repairs for the second time, but the reactor proper has functioned extremely well.

Unusually well instrumented.—The current fuel removal work was cited as another example of Shippingport's value. Problems encountered to date have indicated design changes to facilitate fuel removal which will be reflected in subsequent Shippingport cores and in those of other reactors as well.

However, some of the difficulties, such as those caused by the extensive instrumentation assemblies, are inherent in a developmental reactor like the PWR. Much more can be learned about what actually happens in the PWR core under various conditions, the APPA group was told, than will be possible in other large power reactors, which will not be as heavily instrumented.

Illustrates cost prediction problems.—Although not mentioned by the AEC representatives, the Shippingport trip also indicated that the prevalent practice of estimating future nuclear power costs to the nearest one-hundredth of a mill is probably both idle and misleading. Thus, the complete lack of experience in the utility industry with removing and replacing reactor fuel makes it impossible to predict operating and maintenance costs with much certainty, yet both the manufacturers and the AEC use figures as precise as 0.86 mill/kilowatt hour, for example, in estimating the O. & M. cost for reactors not yet designed or built.

Precise estimates misleading.—Such other uncertainties as actual plant capacities, actual fuel life, and the real costs of fuel reprocessing and waste disposal make precise estimates of other unit costs equally hazardous at the present time. Utilities should not assume that most of the technical problems of economic nuclear power are solved just because industry and the AEC have adopted the practice of estimating the cost of power from future reactors far more precisely than appears to be justified by the present state of knowledge.

Appendix 6

Remarks by Frank K. Pittman, Director of Reactor Development, U.S. Atomic Energy Commission for Presentation at the 1959 Annual Conference of the Atomic Industrial Forum, Sheraton Park Hotel, Washington, D.C., November 3, 1959

POWER REACTOR POTENTIALS

Ladies and gentlemen, it gives me great pleasure to be able to talk to you today on the subject of power reactor potentials. The Commission's civilian nuclear power program may be said to date officially from the passage of the 1954 amendment to the Atomic Energy Act. During the first 5 years of this program, much has been accomplished. Major research and development programs have been carried out by the Government and by industry, with the result that sufficient information has been generated on eight separate reactor systems to indicate that it is technically feasible to use them for the generation of electric power. For some of these concepts, there have been, or are now being, constructed power producing prototypes which will gather the operating experience and economic data needed to show the way to economic nuclear power.

As we review the results of the first 5 years of operation of the U.S. nuclear power program, it becomes evident that there is now need for a careful evaluation of the national effort and a determination of the program that should be pursued during its next phase. The project which we have undertaken to accomplish this evaluation has become known, both within the AEC and in industry, as the 10-year program. It is my purpose during the next few minutes to discuss with you the status of this study and the conclusions which we have reached concerning the economic potential of the several reactor concepts which we now have under active investigation.

First I would like to say a few words about the procedures which we have followed in carrying out the project. In order to develop any sensible long range program, it was necessary that we first have as a starting point a clear understanding of the current status of the several concepts which make up our current program. In addition, we need the best possible analysis of the potential of each concept, the scope and cost of the development and construction program needed to achieve its potential, and the time when the potential could be realized.

We have now completed those phases of the study which establish the current status and which gives us preliminary answers concerning the potential of each of the concepts. In developing this information, we have taken full advantage of the talents, knowledge, judgment, and know-how of persons within the Commission and its laboratories and from the U.S. nuclear industry. Based on the contributions of these persons and incorporating adjustments and evaluations made by the staff, we have prepared a report entitled "Summary of Current Status of Reactor Concepts." This report is now being printed and will be available for distribution early next year. We have also prepared a preliminary draft report entitled, "Economic Potential and Development Program." This report will be used by the Commission and its ad hoc advisory committee as one tool in the development of the long range program. The information which I am presenting today is the first public discussion of the contents of this second report.

Before discussing the details of our analysis of the potential of the various concepts, I would like to spend a few minutes discussing just what was and was not covered in the study.

To begin with, we have considered only those concepts which have sufficient technical bases to allow us today to assume technical feasibility, and we have projected development programs only to the extent that it is reasonable, on the basis of our present knowledge, to foresee success. Aside from nuclear superheat, no major modification of concepts as we now know them was assumed.

For example, we have not attempted to introduce into these studies the effect of variable moderation or spectral shift on the potential of the water concept—we have not tried to factor in the long range effects of programs such as turret or pebble bed on the gas cooled concept—our analysis of the fast reactor systems did not attempt to give weight to the potential impact of the Los

Alamos molten plutonium reactor experiment. We made no attempt to study the potential of other moderators such as graphite or D_2O when used with organic coolants; we did not analyze the use of graphite moderation in water systems; we made no attempt to determine the potential of epithermal reactor systems; the possibility of open or closed cycle gas turbine systems was not evaluated. Furthermore, we made no assumptions that the current charges for reprocessing and transportation would be decreased, that waste disposal techniques would be improved, or that there would be major cost reductions as a result of high volume throughput in fuel fabrication. I dwell on this subject in order that it be clearly understood that our studies and the figures which give today were based on what seems to be the potential of these systems which have today progressed to the point where large scale plants are in operation or will soon be. We have not projected ourselves into the realm of unproven concepts.

The studies which we have now undertaken and which I am discussing today are only the first in a continuing series. The omissions which I have discussed, together with others, will be factored into our future studies.

Now that I have, I hope, made clear what is not covered by the study, I would like to say a few words about the ground rules and assumptions which went into the study we did make. I do this so that you may better interpret the results and assign a confidence level to the figures which I will present. We have attempted to follow ground rules which are neither unreasonably optimistic nor unduly pessimistic. The extent to which we have achieved this balance is a matter of opinion and judgment, and I am sure we will be subject to criticism on both sides. If the number of critics on each side is roughly equal, I will assume that we have reached a reasonable balance.

Some of the assumptions that are on the optimistic side are—

1. All research and development and engineering test programs were successful.
2. A load factor of 80 percent was in effect.

Offsetting these factors are some which could well be considered to be pessimistic:

1. No credit is taken for such things as shorter construction times, lower engineering costs, and lower component costs which will undoubtedly come about as the nuclear industry reaches its maturity.
2. All economics were based on a one-reactor, one-turbine station. No credit was taken for multiple-unit stations such as are now being built in England and Russia.
3. It was assumed that operating, maintenance and insurance costs would remain high for nuclear plants.
4. No increase in reactor capacity beyond design power was assumed, although experience has shown that reactors can generally develop much more than design power after they have operated for a reasonable time.
5. No decrease in the cost of uranium 235 was assumed.

In our studies, we have attempted to evaluate the several concepts on a comparable basis. It was, however, not possible to follow ground rules that offered complete consistency among the concepts. For example, by fixing the size of the reference plant at 300 electrical megawatts, we may have established a relative economic potential among the concepts which would not be the same had the reference plant been much larger. Variations in assumed value of plutonium or the assumed cost of uranium 235 would also have slightly different effects on different concepts, as would changes in the inventory charge for uranium or for heavy water. These factors are, however, all considered to be minor deviations in the detailed structure of our study. They do not affect the basic conclusions of our effort.

I would now like to discuss the details of our results on the various concepts. In each case, I will indicate the cost of power from a 300-electrical-megawatt plant that could be built with today's technology without major extrapolation, the areas where we have assumed cost reductions could be made, the extent of such potential reductions and hence the cost of power from the potential plant, the cost of the additional research and development program which would be required to achieve the reduction and the date when construction could be initiated on the potential plant. All cost data are based on an assumed 80-percent load factor, fixed charges at 14 percent, and plutonium value at $12 per gram.

I. PRESSURIZED WATER SYSTEMS

In this country, this system is at present the most technologically advanced as a result of the experience which has been gained in design and operation of the naval propulsion reactors, the Shippingport reactor, and the Fort Belvoir reactor, in the design and construction of such units as the NS *Savannah*, the Yankee Atomic Electric Co. reactor, SELNI, Belgian reactor No. 3, the Saxton nuclear experimental reactor of the Nuclear Experimental Corp., Saxton, Pa., and the various Army reactors, and in the design studies on the small power and process heat reactors. It is not unreasonable, therefore, to find that the power costs from a 300-electrical-megawatt pressurized water reactor that could be built with today's technology, namely 9.28 mills per kilowatt-hour, are lower than from any other type of reactor. This cost consists of 5.05 mills for capital cost, 3.38 mills for fuel cycle cost, and 0.85 mill for operation, maintenance, and insurance.

Our studies indicate that the substitution of primary pumps employing mechanical shaft seals rather than canned rotors, the elimination of external pressurizers, the modifications of the vapor containment, the use of bulk boiling, and the simplification and improvement of control drive mechanisms would allow a reduction in the total capital cost of the plant by 0.65 mill per kilowatt-hour, which makes that cost component for the potential plant 4.40 mills per kilowatt-hour.

More extensive reductions are indicated in the fuel cycle costs for this system. The fuel exposure for the uranium dioxide fuel can probably be increased from the 27,500 megawatt days per ton maximum which is current technology to 40,000 megawatt days per ton. We also think that fabrication costs of stainless-steel-clad uranium dioxide can be dropped from the current level of $110 per kilogram of uranium to $70 per kilogram. These two factors would result in a total reduction in the fuel cycle cost of 0.82 mill per kilowatt-hour which makes this factor in the potential plant 2.56 mills per kilowatt-hour.

We have assumed that the operating, maintenance, and insurance charges will remain at the 0.85 mill per kilowatt-hour level. The total cost for the power from the potential plant in the pressurized water system is thus 7.81 mills per kilowatt-hour.

In order to achieve the gains indicated above, a research and development effort of the order of $20 million will be required between now and 1965. We feel that by proper utilization of existing, or soon to be existing, plants, it would not be necessary to construct more experimental or prototype reactors over and above those now in operation, under consideration, or planned, and that a project aimed at construction of the potential plant could be initiated, concurrently with the research and development program, in the near future.

II. BOILING WATER SYSTEMS

This system is today only slightly less technologically advanced than the pressurized water system. This is due in part, of course, to the fact that it is able to take adavantage of much of the extensive experience and technology developed in the pressurized water system. It is also due to the highly successful operating experience of the experimental boiling water reactor, the Vallecitos boiling water reactor, and BORAX experiments, to the engineering experience that has been gained through design and construction activities of Dresden, Elk River, Northern States, Army reactors, and so forth, and through the design efforts on such units as the SENN (Societa Elettronuclear Nazionale), Ponta Fiume plant, the Humboldt Bay project of the Pacific Gas & Electric Co., and others.

We have estimated that a 300-electrical-megawatt dual-cycle plant could be built on the basis of today's technology to produce power at a total cost of 9.61 mills per kilowatt-hour. This figure is made up of 5.26 mills for fixed charges, 3.47 mills for fuel cycle, and 0.88 mill for operation, maintenance, and insurance.

The capital costs factor of this system could be reduced by simplification of design to eliminate large risers and heat exchangers, by increasing the power density from 28 kilowatts per liter to 50 kilowatts per liter of core, and, by changes in the vapor containment design. The total potential reduction in the capital costs by these changes is 0.95 mill per kilowatt-hour, which brings that component of the potential plant to 4.31 mills per kilowatt-hour.

The reduction in the fuel cycle costs would be brought about by the power flattening which is made possible by high-power density elements, by increasing

the average irradiation of the fuel to 19,000 megawatt-days per ton, and by reducing the fabrication costs for the zirconium-clad uranium dioxide from $140 to $90 per kilogram of uranium. The total potential reduction of the fuel cycle costs which can be brought about by these gains is 1.18 mills per kilowatt-hour which brings this part of the power cost of the potential plant to 2.29 mills per kilowatt-hour. Again, operation, maintenance, and insurance have been assumed to remain constant at 0.88 mill per kilowatt-hour and the total cost of power from the potential plant is 7.48 mills per kilowatt-hour.

In order to achieve these gains, a development program amounting to approximately $20 million must be undertaken in the next 5 years. In addition, it will be necessary to construct and operate a high-power density prototype which will require an additional $25 million. Construction of the 300-electrical-megawatt potential plant could start in late 1964 or early 1965.

III. NUCLEAR SUPERHEAT

While it is not, in our opinion, possible to build a nuclear superheat reactor solely on the basis of today's technology, we feel that this concept offers a fair potential for reducing the cost of power from water reactors—either pressurized or boiling systems. In our study, we conclude that the cost of electricity from a 300-electrical megawatt waterplant would be reduced by 0.73 mill per kilowatt-hour through the use of an integral nuclear superheat system. The cost reduction, which is split 0.43 mill for capital cost and 0.30 mill for fuel cycle, is due primarily to higher plant efficiency and reduction in turbine costs which is made possible by superheated steam. If these reductions are applied to the potential plant in the boiling system, a power cost of 6.75 mills per kilowatt-hour results.

In order to achieve the potential benefits of nuclear superheat, a development program, in addition to others discussed previously under water systems, of the order of $4 million must be carried out between now and 1965 and a nuclear superheat prototype reactor must be built and operated at a cost of approximately $20 million during that period. A 300-electrical-megawatt potential plant incorporating nuclear superheat could be under construction in 1965.

IV. ORGANIC COOLED AND MODERATED SYSTEMS

In this system, the state of knowledge is not as extensive as in the water systems and as a result the cost of power from a 300-electrical-megawatt plant built on today's technology would be 11.45 mills per kilo-watt hour. This figure is made up of capital costs of 4.39 mills, fuel cycle costs of 5.72 mills, and operation, maintenance and insurance costs of 1.34 mills. The lower capital cost for this system, made possible because of its low pressure, noncorrosive aspects, is more than offset by the high fuel-cycle costs resulting from the low exposure which can be achieved in the metal cores of current technology and by the high operating costs which are occasioned by the necessity for replacing the organic materials as it is destroyed by reactor irradiation.

The potential of this system lies in the development of a new fuel element and cladding material which can achieve much longer life, in increasing the power density from 19 to 44 kilowatts per liter of core, and in increasing the heat transfer capabilities of the system. The studies which we have made indicate that the necessary results can be achieved and that the cost of power from the 300-electrical-megawatt potential plant would be 7.10 mills per kilowatt-hour, of which 3.65 mills are due to capital costs, 2.11 mills to fuel cycle costs, and 1.34 mills to operation, maintenance and insurance.

In order to achieve these results, it would be necessary to undertake a research and development program amounting to approximately $40 million between now and 1965. In addition, $30 million is needed for the construction and initial operation of a 75-electrical-megawatt prototype reactor. Construction of the 300-electrical-megawatt potential plant could be initiated in 1965.

V. SODIUM GRAPHITE SYSTEM

The operating experience of the sodium reactor experiment, together with the experience of the naval reactors and the fast reactors programs, has indicated that it is technically feasible to use the sodium graphite system to produce power. We have estimated that power costs from a 300-electrical-megawatt plant based on current technology would be 11.22 mills per kilowatt-hour,

of which 6.11 mills are for capital costs, 4.12 mills for fuel cycle, and 0.99 mill for operation, maintenance, and insurance.

In order to realize the potential of this system, it will be necessary to develop a new fuel material—the uranium-molybdenum elements on which current technology is based offer very little potential for reduction in fuel cost. However, by developing uranium carbide as a core material, by achieving a core life of 17,000 megawatt days per ton, and by lowering fabrication cost for stainless-steel-clad uranium carbide elements to $70 per kilogram of uranium, the fuel-cycle costs for this system would be reduced to 1.92 mills per kilowatt-hour.

In addition by developing simplified and much less expensive steam generators, by confining the primary cooling system to the reactor vessel, by eliminating moving parts in the sodium stream, and by developing a calandria core to supersede the canned moderator core of current technoolgy, it will be possible to reduce the capital costs of the plant by 1.19 mills per kilowatt-hour. It is also expected that increased knowledge of sodium handling systems will allow operating costs to be reduced by 0.05 mill per kilowatt-hour.

Taking into consideration all reductions which can reasonably be expected to be achieved, the cost of power from the 300-electrical-megawatt "potential plant" will be 7.71 mills per kilowatt-hour of which 4.81 mills will be for capital costs, 2 mills for fuel cycle and 0.90 mill for operation, maintenance, and insurance.

To accomplish this program, a development program, including the operation of the Hallam nuclear power facility and the sodium reactor experiment, of the order of $82 million will be required between now and 1967. In addition, $50 million will be required for construction of a 75-electrical-megawatt prototype reactor. Such a program would make it possible to start construction of the 300-electrical-megawatt "potential plant" by 1965 or early 1966.

VI. GAS COOLED REACTOR SYSTEMS

Gas cooled technology in this country is not in a highly advanced position, since it is only quite recently that work in this field has become an important factor in our overall program. In spite of the fact that no gas cooled power reactors have been built or are even in an advanced state of design in this country, we feel that British experience on natural uranium gas cooled reactors, plus the extensive development work which we have done in this country on enriched fuels, gives us the current technology on which we can base estimated power costs from a plant that can be built at this time. These costs are 11.89 mills per kilowat-hour for a natural uranium gas cooled reatcor system and 10.36 mills per kilowatt-hour for an enriched system—this latter figure has a 5.97-mill component for fixed charges, 3.21 mills for fuel cycle, and 1.18 mills for operation, maintenance, and insurance.

Since our studies show that enriched systems have a greater economic potential than natural uranium systems under U.S. utility economics, we have not, at this time, attempted to determine the potential of the natural uranium fueled-gas cooled systems.

For the enriched system, our studies indicate that by increasing the bulk outlet temperature of the system from 1,050° F. to 1,200° F., by increasing the system pressure from 300 to 400 pounds per square inch, and by increasing the power density from 5 to 8 kilowatts per liter of core, the capital cost component of the power cost could be reduced by 1.57 mills per kilowatt-hour, to 4.40 mills per kilowatt-hour.

As in the case of other systems, the basic reductions in fuel cycle costs are predicted to be due to lengthening life and reducing fabricating costs. In this system, it is estimated that the life could be extended from 10,000 to 14,500 megawatt-days per ton and that the fabricating cost for the elements could be reduced from $110 to $70 per kilogram of uranium. This would bring about a total reduction of fuel cycle cost of 0.40 mill per kilowatt-hour, to make this component of the cost of the "potential plant" 2.80 mills per kilowatt-hour.

A further cost savings is indicated if CO_2 can be substituted for He as the coolant. This would reduce operation and maintenance costs by 0.40 mill per kilowatt-hour. Based on all potential gains, the estimated cost of power from the 300-electrical-megawatt "potential plant" would be 7.67 mills per kilowatt-hour.

The costs of the development program necessary to achieve this potential is of the order of $100 million between now and 1968. This is exclusive of the $14,500,000 research and development program which is aimed at the high tem-

perature unclad fuel prototype being constructed by Philadelphia Electric for $24,500,000. In addition, it will be necessary to construct the $30 million experimental prototype which has already been authorized and which is now under construction at Oak Ridge.

Construction of the 300-electrical-megawatt "potential plant" could be initiated by 1966.

VII. HEAVY WATER MODERATED NATURAL URANIUM SYSTEMS

The practical technology of heavy water moderation for power-producing reactors is not far advanced in this country. However, the basic technology for this system has been developed through research and development programs, and much useful engineering and scientific technology in this field is available from the design, construction, and operation of the production reactors at Savannah River. In addition, a vast amount of basic and engineering information has been generated by the Canadians, who have placed major emphasis on this system. Taking all these factors into consideration, and recognizing that the figures do not have the same degree of backup as those based on current technology for other systems, we have concluded that the cost of power from a 300-electrical-megawatt pressure vessel nonboiling plant built on "today's technology" would be 12.50 mills per kilowatt-hour of which 7.05 mills are for capital cost, 4.22 mills for fuel cycle, and 1.23 mills for operation, maintenance, and insurance.

Because this system is in an early state of development, the potential gains which can be predicted with reasonable assurance are fewer in number and of less certainty than for other systems on which we have a greater background of current technology. However, we are satisfied that by the development of a pressure tube reactor instead of a pressure vessel type, and by achieving an increase in power density from approximately 26 kilowatts per liter, which we feel is currently possible, to 35 kilowatts per liter, we could reduce capital costs by approximately 1.25 mills per kilowatt-hour to a level of 5.80 mills per kilowatt-hour.

Our analysis also shows that it is reasonable to increase the exposure lifetime of the fuel from 3,850 megawatt-days per ton, assumed as possible with current technology, to 7,000 megawatt-days per ton during the next few years, and also to decrease the cost of fabrication from $50 to $15 per kilogram of uranium. These improvements would lower fuel cycle costs by 3.01 mills per kilowatt-hour to a "potential figure of 1.21 mills per kilowatt-hour."

We are not able to predict any decreases in operation and maintenance; however, insurance could be lowered by 0.04 mill per kilowatt-hour, resulting in a new total of 1.19 mills per kilowatt-hour.

The cost of power from the 300-electrical-megawatt "potential plant" is thus 9.03 mills per kilowatt-hour.

In order to achieve the gains indicated, it will be necessary, in addition to the program associated with the reactor project of the Carolinas Virginia Nuclear Power Associates, to undertake an $80 million research and development program between now and 1967, and also to undertake a construction program in the neighborhood of $175 million. Construction of the "potential plant" could be initiated in 1967 or 1968.

I am sure that all of you recognize that our evaluation of the potential of the heavy water natural uranium system is not completely consistent with that of the Canadians. In this respect, it must be recognized that our evaluation is based on U.S. economic conditions and that theirs is based on Canadian conditions. It must also be remembered that the "current technology" is much more firm in Canada—they are much more at home in this system than we are. The differences are matters of judgment, and only time and an intelligent program of research and development and plant construction will show which evaluation, if either, is correct.

VIII. FAST REACTOR SYSTEMS

Technical feasibility of the fast reactor system has been demonstrated by operating experience of experimental breeder reactor No. 1. In addition, the design and development programs which have been carried out for experimental breeder reactor No. 2 and the Enrico Fermi atomic powerplant have given us the basis of a current technology on which could be based the design

of a 300-electrical-megawatt plant capable of producing power at a cost of 13.25 mills per kilowatt-hour. The components of this cost are 5.10 mills for capital cost, 7.10 mills for fuel cycle, and 1.05 mills for operation, maintenance, and insurance.

Capital costs may be lowered approximately 0.67 mill per kilowatt-hour by reducing the thickness of the reactor shield, by simplifying design of pumps and inert gas system, by improving and simplifying piping layout and fuel loading and unloading mechanism, by increasing the temperature rise in the reactor and the temperature drop through the intermediate heat exchanger and steam generator, by decreasing pump and pipe size, and by improvements in instrumentation.

Major cost reductions can be realized by substituting a cermet fuel for the uranium-10 percent molybdenum alloy which is the fuel of current technology. The use of such fuel would reduce fuel cycle costs from 7.10 mills per kilowatt-hour to 1.99 mills per kilowatt-hour.

No credit is taken for lowering operation, maintenance, and insurance costs. Total cost of power from a 300-electrical-megawatt "potential plant" is 7.47 mills per kilowatt-hour.

In order to realize the potential gains of this system, it will be necessary to carry out a development program between now and 1968 in the amount of approximately $160 million, exclusive of money spent on the Fermi plant, and, in addition, to build a prototype plant at an estimated cost of $55 million.

The 300-electrical-megawatt "potential plant" construction could be started in 1968 or 1969.

IX. THERMAL BREEDER-AQUEOUS HOMOGENEOUS SYSTEMS

Our studies have indicated that technical feasibility of the aqueous homogeneous reactor system as a thermal breeder has not yet been demonstrated. I therefore will not discuss the cost of power from a plant based on current technology. However, there is a sufficient background of technology on this system to allow us to predict with, of course, somewhat less certainty than in other cases, the potential of this system. Power from a 300-electrical-megawatt "potential plant" is estimated to cost 11.33 mills per kilowatt-hour, of which 6.38 mills are due to fixed charges, 2.12 mills to fuel cycle costs, and 2.83 mills to operation, maintenance, and insurance.

In order to achieve this objective, it is necessary to undertake a broadly scoped research and development program in the amount of approximately $75 million between now and 1970, and, in addition, to construct a 5- to 10-megawatt experimental reactor (breeder reactor experiment No. 3), a 110-thermal-megawatt-thermal breeder experimental reactor, and a prototype reactor plant of 125-electrical-megawatt capacity. The cost of those plants is approximately $100 million.

On this schedule, it is possible that a 300-electrical-megawatt plant could enter the design and construction phase by 1970 or 1971.

CONCLUSIONS

From the studies which we have made, and with full recognition of the degree of uncertainty that is inherent in any cost estimates in this field, certain conclusions may be drawn:

1. No reactor system can be constructed on the basis of today's technology which can compete with power from conventional systems using fuel costing less than 54 cents per million British thermal units. In this and the following comparison, by the way, I am assuming a conventional plant of 300-electrical-megawatt capacity and a load factor of 70 percent.

2. Six of the reactor systems can become competitive with conventional plants using fuel costing in the range of 35 to 40 cents per million British thermal units.

3. Of the six systems which could compete in areas having conventional fuel costs in the range of 35 to 40 cents per million B.t.u., the pressurized water system could do so at the earliest date.

4. The potential of the water systems, with nuclear superheat, and the organic system is essentially equal from the standpoint of power cost, time when the potential can be achieved, and development costs needed to reach

the goal. Other systems will require 1 to 4 years longer to reach their potentials and will require two to three times as much development effort.

In closing, I would like to emphasize once more that the studies which I have reported on here today represent only one small part of the continuing evaluation and analysis program which will play an ever increasing part in developing our national nuclear energy program. The figures I have given and the conclusions I draw today are as important for what they leave unsaid as for what they say. The figures have all the uncertainties that are inherent in any predictions based on the results of experimental programs yet to be undertaken and on the operation of plants not yet built—or in many cases not yet even designed. In developing the figures, we were naturally forced to use a fair share of technical and scientific judgment. I can only hope and request that an equal degree of understanding and judgment is exercised by those who will use and quote the figures.

APPENDIX 7

[Excerpt from Forum Memo, March 1960]

AEC'S 10-YEAR REACTOR PROGRAM

Having announced that projects demonstrating economic nuclear power in limited areas of the United States may already be on the verge of reality (see above), McCone then unfolded to the Joint Committee the focus of interest in this year's "202" hearings—the AEC's newly developed "10-year plan" for civilian power reactor development, designed to make nuclear power broadly competitive.

The program foresees the expenditure of an estimated $1.71 billion from 1961 through 1969 for reactor development, including reactor experiments and prototypes, but not full scale plants on utility systems. This will come to an average of $180 to $200 million per year. Expenditures programed for fiscal year 1961 are $255 million, compared with $202 million in fiscal year 1959 and an estimated $285–290 million in fiscal year 1960, indicating that the plan foresees some retrenchment from the current level of effort

The total money will be allocated approximately as follows: $700 million for research and development on specific concepts (including at least six foreseeable reactor experiments), $365 million for at least 14 foreseeable prototypes, and $645 million for general engineering support and experimental facilities. Anticipated expenditures for individual reactor concepts are outlined in the accompanying table.

Industry role

The bulk of these funds, the AEC said, is to be paid by the Government, but "industry is expected to make a substantial contribution." The AEC also pointed out that it was not attempting to forecast what projects industry would undertake independently outside the 10-year plan, but expected these to be substantial.

The AEC said it plans to continue the Government-industry division of effort along the lines used in the past: "Reactor experiments should be built and operated by the Commission. Prototypes should be built and operated by publicity or privately owned utilities independently or in cooperation with the Commission; alternatively, prototypes could be built and operated by the Commission. The utility industry should assume the primary responsibility for large commercial size nuclear power stations; however, the Commission will consider possible assistance on initial plants in various concepts useful for demonstration purposes."

AEC 10-YEAR PLAN EXPENDITURES

During his testimony to the Joint Committee on Atomic Energy in last month's "202" hearings, AEC Chairman John McCone presented the following estimated breakdown of the $1.71 billion tentatively expected to be spent by Government and industry through 1969 under the AEC's 10-year reactor development program.

[In millions]

Reactor type	R. & D. including experiments	Prototypes	Total
PWR	$70	$70	$140
BWR	50	45	95
Superheat	50	30	80
OCR	70	30	100
Sodium fast	140	30	170
Sodium thermal	25	30	55
Gas cooled	100	30	130
Heavy water	55	0	55
Aqueous homogeneous	80	20	100
New concepts	60	80	140
Total	700	365	1,065
General engineering support and facilities			645
Total			1,710

Interestingly, the new 10-year plan makes no reference whatever to the possibility of a capital subsidy for private nuclear powerplants, nor does the AEC's new authorization bill for fiscal year 1961 (see below). The omission appears to indicate that the AEC has abandoned the capital subsidy idea, which it proposed and defended last year before the Joint Committee (see "Search for a Formula," "Memo" for April 1959).

Timetable

As to the time schedule for specific future projects related to various reactor types, the 10-year plan foresees the following:

Pressurized water.—Design could begin in 1962 and construction in 1963–64 on one prototype of unspecified size, if justified by R. & D. results and operating experience.

Another prototype of the "spectral shift" variation, possibly 50–100 electrical megawatts, could be initiated in the early 1960's if it appears promising after development work. (AEC described "spectral shift" as follows: "Initially a high concentration—75 to 80 percent—of heavy water is used. As the fuel burns the concentration of heavy water is reduced [by addition of light water]—to about 25 percent—in order to decrease the neutron diffusion rate which increases reactivity and extends fuel life.)

A utility decision to build a large plant could probably be made now on economic grounds in high fuel cost areas, according to the plan.

Boiling water.—Initiation of construction of a 20–30 electrical megawatts prototype geared to development of small power reactors may be indicated in 1963–64.

The question of whether any additional prototypes geared to large reactors are needed will be considered in the light of operating experience available in 1963–64.

A utility decision to build a large plant could probably be made now on economic grounds, said the plan.

Nuclear superheat.—A 100 electrical megawatt prototype, if justified, probably would be initiated in 1963. Cost will probably reach a competitive stage by 1968–69.

Organic cooled.—A 50–100 electrical megawatt prototype may be justified in the middle 1960's. Costs will probably reach a competitive stage by 1965–66.

Sodium cooled fast.—Detailed design and construction of a 100 electrical megawatt fast or epithermal prototype could begin in 1963–64. Costs will probably reach a competitive stage by the late 1960's.

Sodium cooled thermal.—No additional prototype will be considered until Hallam operating experience is available in 1963–64. No forecast is made regarding competitive costs.

Gas cooled enriched.—A 100 electrical megawatt prototype of either the EGCR (Oak Ridge) or HTGR (Peach Bottom) type, depending on the results of comparative evaluation, could be initiated in the middle 1960's. Costs will probably become competitive by the early 1970's.

Heavy water.—An evaluation as to whether utility construction is justified on economic grounds can probably be made by 1966 or 1967.

Aqueous homogeneous.—The 10-year program states that a third reactor experiment could be considered in 1962–63 and should demonstrate breeding or at least a high conversion ratio. If this proved successful, a 50 electrical megawatt prototype could be initiated in the late 1960's. In presenting the program to the Joint Committee, however, AEC Chairman McCone omitted reference to future aqueous homogeneous projects in the light of the second leak recently developed by the Homogeneous Reactor Experiment No. 2 at Oak Ridge (see item in "Technological News," this "Memo").

New concepts

The AEC also said that it will continue to evaluate promising new reactor ideas, and may build three to five new-concept reactor experiments during the next few years, which in turn could lead to the construction of several prototypes. Expenditures for the new concepts program under the 10-year plan are estimated at $45 million for R. & D., $80 million for prototypes and $15 million for miscellaneous facilities.

As typical examples of the new reactor types or modifications now being investigated, the AEC listed the following: Fused salt; fluidized bed; paste or suspended fuel; supercritical water cooled; slurry; advanced epithermal; pebble bed gas cooled; solid moderated, steam cooled; and fast reactors using such coolants as mercury, lead, lithium and sulfur.

The 10-year program also includes continued and in some cases increased efforts in the technological areas of fuels and materials, fuel reprocessing, environmental investigations and waste disposal, physics, reactor components and equipment, and reactor safety.

While the program is aimed at competitive power and therefore tends to stress large central station plants, the AEC said that "this should not be construed as indicating a diminution of Commission interest in, or support of, a small power reactor program directed to achieving economically competitive nuclear power in plant sizes below 50 electrical megawatt." The AEC also noted that it is examining its test reactor needs under the 10-year plan, including possible requirements for fast breeder fuel element test facilities, and is not neglecting the power-related areas of process heat, maritime and military reactors.

Objectives

As to the objectives underlying the 10-year program, the AEC said it still aims at achieving competitive nuclear power in high cost areas of the U.S. by 1968 (i.e., 10 years from announcement of the objective in 1958), and at extending competitive nuclear power to wider areas through a continuing long-range development program. High cost fuel areas are defined to be those where fossil fuels presently cost 35 cents per million Btu or more. The AEC has produced an interesting new definition of "competitive" nuclear power—namely, the point when "utility executives can make a decision to build nuclear stations on the basis of economic considerations over the life of the reactor."

Maintenance of U.S. leadership in civilian nuclear power technology also still remains an objective. The AEC said, however, that conditions relating to two of the nuclear power objectives it developed in 1958 have changed substantially.

With regard to one of these, having to do with the achievement of economic nuclear power abroad within five years, the AEC said: "In the last 2 years the increased availability of fossil fuels and the drop in their shipping costs have brought the time table of achieving economic nuclear power in Europe closer to that of the United States."

With regard to the other, having to do with the development of breeder reactors to conserve uranium–235, the AEC said: "At the present time it is not possible to make an accurate prediction of the time when uranium shortages and rising costs associated with such shortages will make the more efficient use of source material a vital factor. The ultimate importance of conservation of nuclear fuel, however, dictates a long-range program to develop the breeding potential inherent in both the uranium–238—plutonium and the thorium—uranium–233 fuel cycle."

The AEC also pointedly stressed the need for flexibility in the 10-year program it outlined, noting that it must be "adjusted from year to year to take full advantage of the evolving technology." Unlike the AEC report on reactor concept potentials, prepared as backup for the 10-year program and summarized by Reactor Development Director Frank Pittman at the forum's annual conference last fall (see memo for November 1959, p. 6), the 10-year plan does not contain expected power costs detailed in mills per kilowatt-hour for the various concepts.

Reception

Both McCone and the 10-year program (which was unanimously supported by the members of the Commission) were received cordially by the Joint Committee. Senator Anderson called the program a "milestone in Commission planning," although he added: "I note a big gap in prototype construction with no starts from now until fiscal year 1962. What is going to happen to our atomic equipment industry during this 2½-year period?"

In his remarks opening the hearings, Senator Anderson also stated:

"Last year you may recall there were a few misunderstandings on both sides in relation to your presentation. I am glad to say that our subsequent hearings and activities developed the most cordial relationships between the Commission, the Committee, and its staff. In saying this I must recognize that we had some disagreements on proposed atomic power projects initiated by the Joint Committee, or in which the Joint Committee was interested, such as the Oak Ridge gas-cooled experimental prototype; the Puerto Rican nuclear superheat project; the boiling water project in the second round; and the organic prototype in the third round of the power demonstration program. I am glad to say that the Commission after some consideration has proceeded with the projects as contemplated by the Joint Committee on Atomic Energy."

Industry views

As to how the proposed AEC reactor program for the next 10 years was received outside the Government, the following comments were given by organizations presenting testimony during the 202 hearings:

Pioneer Service & Engineering Co.: "Thoughtful and well-conceived."

Kaiser Engineers: "Essentially in agreement with the objectives."

General Electric Co.: "Cannot commend too highly the spirit and the effort evident."

Vitro Corp. of America: "There is much in the announced program which deserves our complete support."

Consolidated Edison Co. of New York: "Provides a reasonable framework for concentrating on certain reactor types which show promise of achieving economic power in a relatively short time."

National Rural Electric Cooperative Association: "We are somewhat shocked and dismayed by the proposal in that we feel the program proposal rather than signifying a great step forward, carries out in effect the policies of the previous Chairman of the Atomic Energy Commission. * * * The proposed 'new starts' by the AEC as detailed in their program report calls for, in effect, no new starts prior to either 'the early 1960's' if promising, or 1963 or 1964."

AFL–CIO: "Too little and too late."

Atomics International: "Valuable first step."

Edison Electric Institute: "The current program underway is substantial and * * * adequate."

American Public Power Association: "Very valuable step forward. * * * However, the AEC 1968 goal [for achieving competitive power] as AEC defines it seems to be not so much a specific technical goal as a state of mind [and] appears achievable at almost any time at the will of utility executives. * * * The lack of any proposed new starts is most disappointing."

Diversification

In addition, some of the industrial testimony proposed increased attention to specific reactor types, as in the following comments:

Vitro Corp. of America: "We would urge that * * * consideration be given to advancing the present plan to develop thorium concepts."

American Radiator & Standard Sanitary Corp.: "We urge that the level of research and development support for newer and theoretically promising reactor concepts be increased * * * Our fast breeder reactor cooled with boiling mercury * * * could operate at 1,000° F., using commercially available low alloy steel for fuel cladding and structures."

Atomics International: "It is evident from the [10-year plan] document that, in the opinion of the AEC, the light-water reactors will soon be salable to the utility industry on a competitive power cost basis. This present status of the light-water reactor concept is a demonstration that a sound technical approach can be brought to a commercial position with sufficient support. Substantially less support could bring other concepts to the forefront * * *. We believe it is timely to initiate in fiscal year 1961 the construction of a second sodium reactor experiment."

General Dynamics Corp.: "We are * * * more optimistic as to the future of gas-cooled reactors than the Commission. * * *"

APPENDIX 8

ADVANCED TECHNOLOGY LABORATORIES,
A DIVISION OF AMERICAN-STANDARD,
Mountain View, Calif., March 8, 1960.

Hon. CLINTON P. ANDERSON,
Chairman, Joint Congressional Committee on Atomic Energy,
Washington, D.C.

DEAR SENATOR ANDERSON: Members of your committee requested additional information on our mercury-cooled breeder reactor program, following a description given by Mr. John C. Linsenmeyer, executive vice president of our corporation, before the committee on February 24. We appreciate this opportunity to present this information to you, as we consider this program of great promise in the achieving of the national goal of economic nuclear power. The following documents are enclosed in compliance with your request.

1. A summary of the current status of the MCBR program and the potential of the reactor type (25 copies).[1]
2. The evaluation report submitted to the Commission in December 1959 (ATL–A–102) (2 copies).[1]
3. A proposed program for the future development of the MCBR (ATL P-1035) (10 copies).[1]

Since our appearance before your committee, we have received an answer from the Commission on the above-mentioned proposal. In lieu of the complete program as proposed, the Commission has requested us to submit a proposal to do a small amount of additional work covering the kinetics of this reactor system. It is our intention to comply with the Commission's request, and more kinetics information is certainly of importance. However, as we have indicated to the Commission, we remain of the opinion that this new concept is sufficiently attractive to warrant planning for and initiation of a more extensive program; namely, one which will permit a much earlier realization of its potential. Indeed, we feel that the program we originally proposed could be initiated now, as it included the kinetics work suggested by the Commission plus those additional tasks required at this time to realize an early construction date.

It is pointed out that the total cost of the development program leading to and including the design of a 100-electrical-megawatt prototype powerplant of the MCBR type is estimated to be less than $10 million. The capital cost savings alone realized by constructing a mercury-cooled breeder reactor in lieu of a sodium-cooled breeder reactor of the 100-electrical-megawatt size is considerably more than this figure. Thus, we feel that the development program as originally submitted is well worth while.

American-Standard's interest in this project is exemplified by its own support of experimental work in this area. As was pointed out during our testimony, we have constructed and operated small-scale heat transfer experiments which have already extended the technology for mercury systems by a factor of 3. Thus far we have found no limit experimentally to the possibilities of high performance from mercury systems. We have also continued our design investigation of the MCBR system, and have concluded that a direct cycle shows even greater promise than the indirect cycle which was the basis for our work under Commission contract.

We have made a preliminary projection of MCBR costs into the future, so as to compare the potential of this system with other reactor types indicated in the Commission's 10-year program. The potential cost for the MCBR of 7.3 mills per kilowatt-hour obtained under the same ground rules as the Commission's own estimates, compares quite favorably with the Commission's projected 7.5 mills per kilowatt-hour for sodium-cooled breeder plants. The cost of a program to realize this potential in the MCBR appears to be but a small fraction of that postulated by the Commission to achieve the potential of a sodium-cooled system. Indeed, in its own evaluation of fast breeder reactors, the Detroit Edison Co. concluded that a major area for potential improvement is the "devel-

[1] On file with the Joint Committee on Atomic Energy.

opment of a primary coolant that satisfies plant requirements better than sodium." Mercury as a primary coolant definitely appears to satisfy plant requirements better than sodium, since it is far less hazardous, entails less equipment, gives higher thermal efficiencies, and is backed by years of existing plant technology.

As was stated in the testimony, our work is based on existing materials technology. Lack of consideration of this point has been perhaps the major cause of discouragement with many of the new reactor concepts on which considerable research and development funds have been expended to date without realizing the anticipated results. With such a firm basis for this new concept, we recommend that the mercury-cooled breeder reactor form an integral part of the Commission's overall program for the development of an economic fast breeder power system.

If there are any questions on the enclosed material, we would be pleased to answer them at your convenience.

Yours very truly,

E. J. WILSON, Jr., *President.*

APPENDIX 9

[Excerpt from American Municipal Association's "1960 National Policy"]

2. ATOMIC ENERGY

Local communities and local officials have a direct concern and interest in the peaceful applications of atomic energy. The developments in this field mean new processes, new products, and new types of industrial plants in many localities. It also means new considerations in the operation of local government, in the responsibilities of local officials, and the health and safety of local people. Already several thousand firms and laboratories are licensed to use nuclear materials in some 1,500 cities and towns across the country, and the number is increasing.

If local officials are to properly discharge their responsibilities for the health, safety, and welfare of their communities, it is necessary that they be informed about the developments in this field, and the specific community problems that result. In view of the continuing expansion in this field, it is imperative that local communities begin immediate preparations to deal with the impact of the peaceful atom on health, fire, police, planning and other activities of local government. We therefore resolve:

2–1. We urge the Atomic Energy Commission and other responsible organizations including industry to sponsor and assist in the preparation of such specific studies as may be needed to assist local governments to adjust to the impact of peaceful atomic energy activities such as transportation and handling of nuclear materials, disposal of radioactive waste, special training of local personnel, and development of needed local ordinances. Further, that the results of such studies be published and made available in guide form—suitable for use by local officials.

Standards and model codes and ordinances are urgently needed to guide and assist in local programs. Research in this area should push ahead unabated. The National Committee on Radiation Protection, the American Standards Association, and other groups should be encouraged to accelerate their efforts. The Federal Government, professional and industry groups should provide all possible assistance.

2–2. When atomic energy licenses are issued, prompt notice should be given to the communities in which the licensees are to operate. At present, although the locality may be the first to get the impact, it is often the last to know. Delay may be dangerous by causing neglect of essential local protective measures. It may be necessary for the AEC to notify communities directly in order to assure prompt local notification.

2–3. Member municipalities are urged to pass an ordinance requiring those who handle and use atomic or radioactive materials in the community, to register same with local government and that a specific local officer be designated for that purpose. Cities are also urged to consider setting up of proper facilities to monitor the radioactive conditions in the atmosphere, water supply and general environment.

2–4. A central clearinghouse of information on the local impact is urgently needed. At present it is necessary for local officials to make requests to many different offices in order to find out what information is available on such basic matters as standards, training, aand the like. Then, the information is often incomplete. A central clearinghouse of information in this field should be set up on a national basis at the earliest possible time, and its location should be publicized.

2–5. Training is a critical factor in local programs. Prompt effort should be made to build a reservoir of health and engineering personnel with a background in radiation use and protection. This is a long range objective, and will require the cooperation of all levels of government, educational institutions and other groups. Meanwhile, special programs are needed to provide existing local personnel with necessary training. The Federal Government should quickly provide assistance and financial support to stimulate efforts under Public Law 86–373.

ATOMIC ENERGY AND PUBLIC HEALTH

2–6. Important in the consideration of the development of new and challenging applications of atomic energy is the need to safeguard all persons from the dangers of ionizing radiation. The association believes the establishment of a Federal Radiation Council to be a salutory move toward the much needed coordination of Federal agencies involved in this complex problem. The association views with some apprehension the continuation of a situation where no single Federal agency is delegated sole responsibility for the protection of the public's health from the harmful effect of ionizing radiation. In future delegation of authority and responsibility from the Atomic Energy Commission to State governments, as authorized by Public Law 86–373, the AMA urges that cognizance be made of the important role to be played by municipalities and that procedures be established whereby these municipalities can and will be involved in all plans and operations which may affect them.

APPENDIX 10

U.S. DEPARTMENT OF COMMERCE
FREDERICK H. MUELLER, *Secretary*
BUREAU OF THE CENSUS
ROBERT W. BURGESS, *Director*

ATOMIC ENERGY COMMISSION
JOHN A. MCCONE, *Chairman*

FACTS FOR INDUSTRY

For release: January 8, 1960 Series: M38Q–08

ATOMIC ENERGY PRODUCTS, 1958[1]

During 1958, shipments to U.S. Government agencies, to export, and to others, of selected key atomic energy products manufactured in privately owned establishments totaled $148.9 million. This represents an increase of 55 percent above the total value of shipments of these products in 1957. Included in 1958 shipments are $24.2 million of radiation detection and monitoring devices, an increase of 38 percent over 1957; reactor vessels and tanks valued at $17.1 million, an increase of 54 percent above 1957; accessory instrumentation for reactor control valued at $15.3 million, an increase of 53 percent above 1957; complete reactor fuel elements shipped directly for installation or use in a reactor, valued at $23.9 million, an increase of 115 percent above 1957; and heat exchangers, valves, and pumps uniquely designed for nuclear applications, valued at $13.8 million, $11.4 million, and $9.5 million respectively, representing respective increases of 66 percent, 44 percent, and 51 percent over 1957. Shipments of nuclear reactors completely assembled at the place of manufacture, valued at $1.2 million, declined 60 percent below 1957 shipments.

Also included are shipments data for the following products specifically designed for use in nuclear applications: accelerators and accelerator parts; reactor control rod drive mechanisms; pressurizers; partially fabricated fuel materials not shipped directly for installation or use in a reactor; core struc-

[1] Prepared by the Bureau of the Census, Industry Division, Machinery and Equipment.

turals; hot laboratory equipment; radioactive isotopes (shipped from plants producing isotopes); radiation sources and other radioactive materials (produced from purchased isotopes); control and measuring devices containing radioactive isotopes; commercial radiation service; and enriched uranium metal and compounds.

The data in this publication are based on reports received on Form MA–38Q; Atomic Energy Products Shipments Report for 1958. This survey is jointly sponsored by the Bureau of the Census and the Atomic Energy Commission. Data were included from all known manufacturers of selected products specifically designed for use in nuclear applications. Excluded are construction expenditures, engineering and design costs, research and development expenditures, as well as shipments data for products used in atomic energy work which are not especially designed for nuclear applications.

Any inquiries concerning these data should be addressed to the Bureau of the Census, Industry Division, Washington, D.C.

This publication was prepared in the Industry Division under the supervision of Clarence H. Olsen, Chief, Metals, Machinery and Equipment Branch, by Evelyn W. Colburn.

Shipments of atomic energy products, 1958 and 1957

[In thousands]

Product	Value of shipments					
	1958			1957		
	Total	U.S. Government agencies	Other, including export	Total	U.S. Government agencies	Other, including export
Total [1]	$148,932	xxx	xxx	[2] $96,070	xxx	xxx
Nuclear reactors	1,156		$1,156	[2] 2,907	(3)	(3)
Accelerators and accelerator parts	45	(3)	(3)	(4)	(4)	(4)
Reactor components and equipment:						
Reactor vessels and tanks	17,099	$13,325	3,774	[2] 11,145	[2] $10,295	$850
Reactor control rod drive mechanisms	7,481	6,969	512	1,263	722	541
Accessory instrumentation for reactor control	15,284	12,326	2,958	[2] 9,953	[2] 6,771	[2] 3,182
Heat exchangers	13,799	7,358	6,441	8,284	7,925	359
Pressurizers	1,758	(3)	(3)	(2)	(2)	(3)
Pumps	9,516	7,861	1,655	[2] 6,291	[2] 5,599	692
Valves	11,401	7,695	3,706	[2] 7,876	6,201	[2] 1,675
Complete reactor fuel elements shipped directly for installation or use in a reactor	23,873	21,218	2,655	[2] 11,057	[2] 10,629	428
Partially fabricated duel materials not shipped directly for installation or use in a reactor	5,742	3,358	2,384	[2] 4,985	(3)	(3)
Core structurals (barrels, cans, boxes, plates, etc., not included above)	3,908	1,545	2,363	[2] 1,185	[2] 991	[2] 194
Hot laboratory equipment	3,886	2,900	986	4,761	2,540	2,221
Radiation detection and monitoring devices:						
Radiation survey, monitoring, and control devices	13,846	8,699	5,147	17,471	8,422	9,049
Radiation counting equipment	10,387	2,661	7,726			
Radioactive isotopes shipped from plants producing isotopes	171	(3)	(3)	73	(3)	(3)
Radiation sources and other radioactive materials produced from purchased isotopes	3,071	403	2,668	2,722	418	2,304
Control and measuring devises containing radioactive isotopes	4,909	372	4,537	6,007	(3)	(3)
Commercial irradiation service	97	(3)	(3)	(3)	(3)	(3)
Enriched uranium metal and compound	1,503	199	1,304	(5)	(5)	(5)

[1] For 1958, about $13,000,000 of shipments of "other specialized reactor components," which include such products as fuel-handling equipment, shields and shielding assemblies, specialized piping and fittings, etc., were reported. For 1957 about $4,000,000 of shipments of these products were reported. These shipments have not been included in the totals since the coverage of the residual items reported for 1958 and the extent of their comparability with those reported for 1957 is not known.

[2] Revised.

[3] Withheld to avoid disclosing figures for individual companies.

[4] In 1957, included with "other specialized reactor components." See footnote 1.

[5] Not available.

APPENDIX 11

THE AVAILABILITY OF URANIUM FOR A NUCLEAR POWER INDUSTRY

by

R. A. Laubenstein
C. Starr

ATOMICS INTERNATIONAL
a division of North American Aviation, Inc.

ISSUED: FEBRUARY 15, 1960

ABSTRACT

A study of the economically available resources of uranium in the U. S. A. and in the world indicates that these resources will increase rapidly as the price of uranium ore is increased. At present ore prices, available uranium in the U. S. A. should be sufficient to maintain the nuclear power industry in this country until the year 2005. If the U. S. A. were considered as an isolated producer and consumer of uranium, an increase in price of U_3O_8 to $23 per pound would be required to make sufficient uranium available until the year 2050, assuming no advance in nuclear technology. This increase in ore cost would increase the fuel cycle cost by only 0.5 mill per kwh. Predictable improvements in reactor technology, such as improvements in conversion ratio, could easily compensate for this increase in the cost of natural uranium. These improvements would also increase the amount of energy available per ton of natural uranium, although this increase has not been included in the above.

On a world-wide basis, sufficient uranium should be available from known economical reserves to support the nuclear power industry until at least the year 2050 with no increase in the price of uranium beyond the present range of prices.

These general conclusions are reached if the reactor type assumed for nuclear power generation has characteristics similar to a high-temperature, high-specific-power system. For a low-temperature, low-specific-power system, similar conclusions on a partially-reduced time scale would result. The high-temperature, high-specific-power system, which was used as the reference design for this paper, will yield more electric energy per ton of uranium and will be less sensitive to possible increases in its price.

The study indicates that there is appreciable incentive to the development of high-temperature, high-specific-power reactors (such as the liquid metal cooled) as compared with the low-temperature, low-specific-power types (water or organic cooled). For example, present fuel costs for the low T. and S.P. reactors with U_3O_8 at $10 per lb are equivalent to the costs for the high T. and S.P. reactors with U_3O_8 at $26 per lb. Such an increase in permissible ore cost would increase uranium resources by a factor of six.

A large increase in the energy obtained per ton of natural uranium could result from the development of a system for burning plutonium with a reasonably high conversion ratio, such as plutonium recycle or a plutonium fast reactor. The advent of the plutonium breeder (conversion ratio greater than 1) would permit the optimum utilization of the world's potential uranium resources.

I. INTRODUCTION

This paper is a study of the relations between the availability of uranium as a raw material, the world need for energy, and the nuclear performance of reactors. Particular attention has been given to the effect of uranium price on the availability of uranium and on power cost in order to determine under what conditions it may be economic to utilize some of the lower grade ores.

The parallel subject of the availability and utilization of thorium is not discussed in this paper, but will be the subject of future study. Consideration of thorium should not alter the conclusions of the present paper.

The analysis begins with a survey of the reserves and resources of uranium in the U. S. A. and in the world. This survey is contained in Section II. Predictions of the future energy requirements and the fraction of these requirements which will be supplied by nuclear energy are contained in Section III. These predictions of future nuclear energy generation are combined with reactor characteristics in Section IV to give predictions of the future requirements for uranium. A comparison of the reserves and resources of fossil fuels to those of nuclear fuels is contained in Section V. The effect of increases in the price of uranium on fuel cycle economics is discussed in Section VI. Changes in nuclear parameters, such as conversion ratio, are discussed in order to show the influence of improved reactor characteristics on the utilization of uranium and on fuel cycle ecomomics.

In the discussion of costs, only those costs were varied which are directly related to the price of uranium. Fuel fabrication and chemical processing costs were assumed to be fixed and not to vary as reactor characteristics vary. Present technology may be more pessimistic than this; for example, the fuel fabrication and processing charges for fast breeder reactors tend to be higher than for other types. However, as technology advances, these differences should become less important. For similar reasons, capital costs and maintenance costs have not been included in the study.

II. HOW MUCH URANIUM WILL BE AVAILABLE?

A. WHAT ARE URANIUM RESOURCES?

The quantity of uranium which can be economically recovered from the earth in the future can be referred to as uranium resources. Resources are defined as reserves plus potential ore.[1] In the U. S. A., estimates of uranium reserves are published by the AEC, but information on uranium resources is not readily available. It is the resources which should be used as the basis for predictions of the availability of uranium in the long term future.

Uranium is widely distributed in the earth's crust with an average concentration of about 4 parts per million by weight. There are, however, ore bodies which contain various concentrations and quantities of uranium, and from which uranium can be recovered for various costs. Thus, the resources of uranium will depend on the price for which uranium can be sold. As the price of uranium increases, the resources will increase.

An upper limit for uranium resources can be taken as the total amount of uranium available in the earth's crust. This quantity of uranium will be called the resource base[2] and will be a fixed quantity regardless of the price.

B. URANIUM RESOURCES IN THE U. S. A.

Estimates of the domestic reserves of uranium which have been published by the AEC are shown in Figure 1. These reserves include only ore which is economically recoverable at present prices. The estimates are probably conservative, since they are obtained from data on ore bodies which are used as the basis for negotiation of uranium milling contracts. Present reserves of U_3O_8 in the U. S. A. are estimated at about 250,000 tons.

A significant feature of the growth of the reserves in this country is the rapid decrease in the rate of growth around 1956. This corresponds with the time that the AEC indicated that it did not want to enter into new contracts for the purchase of uranium, thereby removing most of the incentives for prospecting for the ore. It would be expected that if the incentives again existed, these reserves would increase substantially.

Also shown in Figure 1 is the yearly procurement of U_3O_8 by the AEC from domestic sources. The yearly procurement has been steadily increasing for the past 10 years, but is expected to level off at about 20,000 tons per year. Present domestic reserves are sufficient to maintain the current domestic production rate for about 14 years.

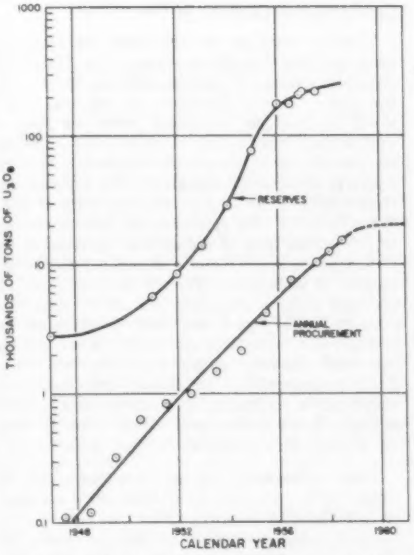

Figure 1. Domestic Uranium Reserves and AEC Procurement from Domestic Sources.

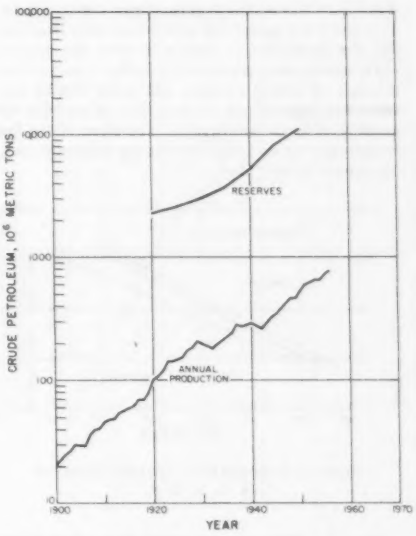

Figure 2. World Production and Reserves of Petroleum.

Another example of the increase in reserves when there is an economic incentive for exploration is the growth in petroleum reserves. Figure 2 shows the growth in the annual world production and the world reserves[4] of petroleum. The reserves remained at 15 to 20 times the annual production during the period 1920 to 1950. Total world resources of petroleum have been estimated by Ayres [5] to be about 185,000 million metric tons, which would be a 250-year supply at the 1955 production rate. These estimated resources are about 17 times the reserves in 1950.

The ultimate availability of uranium will depend on the price which can be obtained for uranium. In the U. S. A., for example, there is an estimated 5 to 6 million tons of U_3O_8 in the Chattanooga shale deposits, which can be recovered at a cost of $40 to $50 per lb.[3] An additional 800,000 tons of U_3O_8 could be recovered from phosphate rocks in the U. S. A. at a similar price with no allowance for recovery of by-product materials. The exact form of the relationship between availability and price is not known, but it can be assumed that the function which relates these variables is continuous and can be approximated by a straight line on a log-log scale.

Present domestic production costs are about $8 to $10 per pound of U_3O_8, and the present reserves at this price are about 250,000 tons. The Chattanooga shale and phosphate rock deposits will thus increase the reserves by a factor of about 25, if the price is increased by a factor of 6. This relationship is consistent with a prediction by J. Sornein[6] that if the price is multiplied by 3, the reserves will increase by a factor of 10. These data are plotted in Figure 3, where the point labeled 1 is the present AEC published reserves and the point labeled 2 represents the Chattanooga shale and phosphate rock deposits.

The possibility of obtaining uranium from igneous rocks, which compose most of the earth's crust, has been investigated by Brown and Silver.[7] Their experiments indicate that the uranium which is readily recoverable averages about 0.85 parts per million, and the cost of recovery is equivalent to $650 to $1400 per pound of U_3O_8. The total recoverable uranium which would be found under the continental U. S. A. to a depth of two miles is 6×10^{14} tons; this is plotted as point 3 in Figure 3. If it is assumed that only 10 percent of this uranium can be recovered and that the higher cost estimate applies, then point

4 in Figure 3 is obtained. It is coincidental that points 1, 2, and 4 in Figure 3 fall on a straight line. However, this line establishes a relation between the price of U_3O_8 and the resources of U_3O_8 in the U. S. A. which is based on known reserves, and hence can be considered as conservative or pessimistic in regard to the quantity of uranium available. The slope of the line is such that the uranium reserves are proportional to the square of the price.

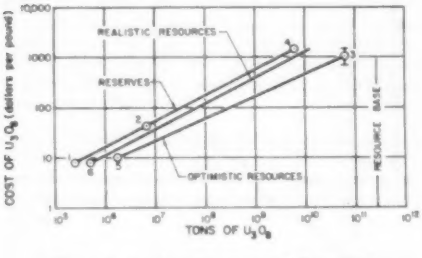

Figure 3. Uranium Reserves and Resources in the U. S. A.

Point 5 in Figure 3 is an optimistic estimate of the uranium resources in the U. S. A. which could be obtained at a price of $10 per pound of U_3O_8 or less. It was assumed for this point that the present reserves could be increased by a factor of four by new discoveries and by extension of present reserves. It was also assumed that the estimated 0.8 million tons of U_3O_8 recoverable from phosphate rocks could be recovered as a by-product material at about $10 per pound and can be considered as reserves. The total optimistic resources in the U. S. at $10 per pound are thus about 1.8 million tons.

A realistic estimate of uranium resources as a function of price is difficult to make. A compromise between the optimistic and the pessimistic estimates discussed above might be considered such a realistic estimate. The line in Figure 3 which is labeled as realistic was based on the assumption that the resources would be only twice the present reserves.

Point 6 on Figure 3, which is the starting point for the realistic curve, corresponds to a reserve of 0.5 million tons of U_3O_8 at a price of $8 per pound.

Based on past experience with the growth of uranium reserves and reserves of oil or other minerals, the present realistic estimates will appear in the future to have been very pessimistic. Thus, it is confidently expected that the uranium resources will be at least as large as the realistic estimates.

C. URANIUM RESOURCES IN THE WORLD

Uranium resources for the world are somewhat more uncertain than those for the U. S. A. The known economic reserves in the free world are about 1 million tons of U_3O_8.[4] Estimates of resources which would be available at present prices are about 4 million tons,[4] based on a probable extension of present reserves and the location of new ore bodies. The total land area in the world, exclusive of the Antarctic and Greenland, is about 18 times the area of the U. S. A. If this factor of 18 is applied to the realistic estimate of 0.5 million tons of economical resources in the U. S., then the world resources at present prices should be about 9 million tons. The 9 million ton figure for the total world is consistent with the 4 million ton estimate for the free world when one considers the uranium in communist countries and in areas of the free world that have not yet been prospected. Thus, it will be assumed that the uranium resources in the world can be represented by a curve similar to that in Figure 3, where the world resources are 18 times the realistic U. S. resources for any given price.

Many estimates of the world uranium reserves appear to be very pessimistic when these estimates are considered as resources rather than reserves. For example, Putman[5] estimates the reserves recoverable at a price up to $100 per pound to be about 25 million tons and Weinberg[6] quotes the reserves recoverable at $30 to $50 per pound to be 20 million tons. These prices are sufficient to enable economic recovery of uranium from low grade bituminous shale and phosphate rock deposits. J. C. Johnson has written:[7] "Low-grade bituminous shale and phosphate deposits contain from $\frac{1}{10}$ to $\frac{1}{5}$ of a pound of uranium per ton and, considering only the larger of the world's known deposits, represent a uranium reserve of more than 20,000,000 tons." In view of the latter statement, it would appear that the world resources in the price range discussed are many times 20 million tons. The resources at a price of $40 per pound of U_3O_8 which are obtained from the curve assumed for the present paper (Figure 3) would be about 240 million tons. The ratio of uranium resources to reserves in this price range is thus less than 12 compared to an estimated ratio for world oil resources-to-reserves of about 17. Thus, the present estimate of 240 million tons for the uranium resources in the $40 per pound price range appears reasonable in relation to the information presently available.

The estimates in the present paper are based on current technology for the recovery of uranium. Future developments in the mining or recovery of uranium from the ore may decrease the cost of uranium.

III. PREDICTION OF NUCLEAR ENERGY PRODUCTION

A. CAN ACCURATE PREDICTIONS OF NUCLEAR FUEL REQUIREMENTS BE MADE?

Predictions of future nuclear energy production are subject to uncertainties in the future total demand for energy and in the relative position which nuclear power will achieve among the various sources of energy. An example of the hazard of predicting the future utilization of a specific type of energy is shown by the energy equivalence of the annual world consumption of coal,[9] which is shown in Figure 4. From 1860 until 1913, the energy equivalence of the world coal production increased at a rate which was very close to an exponential, with a doubling time of 17 years. A prediction made before 1913 probably would have estimated the energy equivalence of the world coal production in 1947 to be about 135×10^{15} Btu, whereas the actual coal production in 1947 was about one-third of this amount. Extrapolation of other data on coal production on a tonnage basis[10] leads to an error of about a factor of four between the actual and predicted 1947 coal production.

Figure 4 also shows the total annual input to the world energy system and the input from commercial sources of energy. In addition to coal, the commercial energy sources include oil, gas, hydro-power, and lignite. The total energy input includes wood, dung, and farm wastes in addition to the commercial sources of energy. Coal production has increased by a relatively small amount since 1913, in spite of an increasing total demand for energy that doubles in about 32 years. Most of the increased energy demand since 1913 has come from oil and gas, which have become strong competitors with coal. Prior to 1913, the rate of increase in annual coal production was greater than the rate of increase in the total energy demand because coal displaced firewood as a principal energy source.

Uranium as a fuel material could develop a usage curve similar to that for coal, with fusion power possibly limiting the future consumption of fissionable and fertile materials. Other types of usage curves could of course evolve. The future consumption will depend on many technical and economic factors which can not be predicted at this time. Therefore, it would appear most reasonable to base future predictions on present day technology or on relatively small extensions of this technology. In this paper, predictions will be projected to the year 2050. Thus, if the technology improves between now and 2050, as can reasonably be expected, the predictions made in this paper will most certainly prove to have been pessimistic.

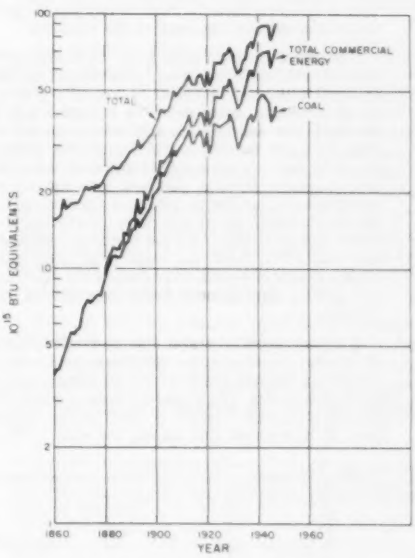

Figure 4. Annual Inputs to World Energy System.

B. WORLD PRODUCTION OF NUCLEAR ENERGY

In the future, nuclear energy will probably be used principally for the production of electrical energy. Predictions of nuclear energy production will therefore be based on a fraction of the total predicted electrical energy production. It will be assumed that military applications such as nuclear submarines will become a relatively small part of the total nuclear energy production and that nuclear process heat will also contribute only a small amount to the use of nuclear fuels.

Robinson and Daniel[11] found that a smoothed curve of the annual world production of electricity could be approximated very well by the equation

$$E = 1130 \times 10^{9}[(t - 1875)/77]^{4.3}$$

where E is the annual electrical energy production in kwh and t is the year. This equation is represented in Figure 5 by the curve labeled "world total" and appears to be a good relation to use for the prediction of future electrical energy production. For the year 2000, the equation gives an energy production of

$9{,}000 \times 10^9$ kwh. Putman[4] estimates an installed electrical capacity of 1800×10^6 kw by 2000. If an equivalent full-power operating time of 5000 hours per year is assumed, then the Putman estimate is equivalent to the estimate obtained by the equation.

The above equation gives a rate of increase of the annual world electrical energy production from 1950 to 1960 which is equivalent to a doubling time of about 13 years. However, it is expected that this doubling time will increase with time since the doubling time for the total world demand for energy is about 32 years. At some time in the future it is reasonable to expect that the doubling time for the total world demand for energy will equal the doubling time for the electrical energy generation. According to the above equation, this condition is not yet reached by the year 2050, since the increase in total annual electrical energy production between the years 2040 and 2050 is equivalent to a doubling time of about 24 years.

It is reasonable to expect that as the development of nuclear power plants continues, an increasing fraction of the new plants which are constructed will be nuclear plants. The projected nuclear energy production shown on Figure 5 is based on this assumption. It is assumed that during the year 1970, 10 percent of the world electrical energy produced by new plants completed in the previous year will be produced by nuclear energy. During each succeeding year, it is assumed that the fraction of the new capacity which is nuclear will increase by 1 percent until the year 2010, at which time half of all new capacity constructed will be nuclear. New capacity was calculated on the basis of additional capacity for growth plus new capacity for replacement of worn-out plants (based on a 30-year plant life). After the year 2010, it is assumed that 50 percent of the new plants constructed will continue to be nuclear. As a starting point for the projection of nuclear capacity, it is assumed that during 1965, 42×10^9 kwh of nuclear electrical energy will be generated, based on an estimated capacity of 8.5×10^6 kw. This capacity would be distributed as follows: UK, 4×10^6 kw; U. S. A., 1.5×10^6 kw; and other countries, 3×10^6 kw.

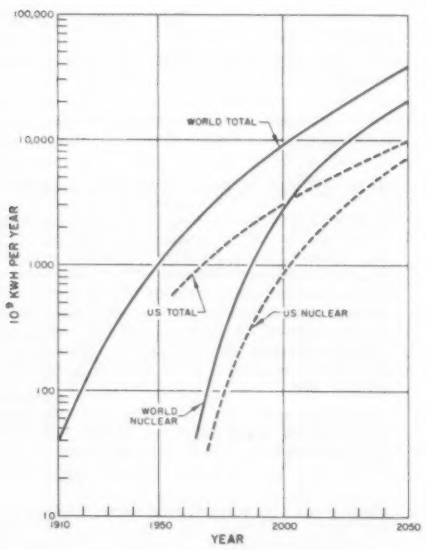

Figure 5. Predictions of Annual Electrical Energy Production.

Many predictions of nuclear electrical energy generation in future years are based on a larger fraction of the total electrical energy being supplied by a nuclear source. The present estimates indicate that 53 percent of the electrical energy will be produced by nuclear sources during the year 2050. It is likely that about 10 percent of the electrical energy at this time will be supplied by hydro-plants. There is no indication that there will be a shortage of coal by this date on a world basis, although coal may be relatively costly in certain areas, as it is today. The possible introduction of the fuel cell as a source of electrical energy on a large scale may also improve the competitive position of fossil fuels in relation to nuclear energy.

C. PRODUCTION OF NUCLEAR ENERGY IN THE U.S.

Of the annual electrical energy produced in the world, the fraction which is generated in the U. S. A. has increased from about 34 percent in 1940 to 41 percent in 1953. Thus, predictions of the future electrical energy production in the U. S. A. which are based on extrapolation of production in recent years have a tendency to intersect and cross over other predictions of total world production. A contributing factor to the recent high rate of expansion of electrical energy production in the U. S. A. is the atomic energy program. In 1956, the AEC purchased 58.5×10^9 kwh of electrical energy, which was 8.5 percent of the total U. S. electrical energy production of 685×10^9 kwh in that year.

Figure 5 shows a prediction of the future annual electrical energy generation in the U. S. A., based on a progressively smaller percentage of the total world generation. For the purposes of this prediction, it is assumed that the electrical energy produced in the U. S. A. in 1960 is 42 percent of the world total and that the percentage produced in the U. S. decreases by 1, each 5 years thereafter. In the year 2050, therefore, 24 percent of the total world electrical energy would be produced in the U. S. A.

The nuclear electrical production in the U. S. A. is estimated from the total U. S. electrical energy production in almost the same manner that the world nuclear energy production is estimated from the total world electrical energy production. The difference is that the fractional nuclear electrical capacity of the new plants constructed each year increases at the rate of 1 percent per year until 2035, at which time 75 percent of the new capacity would be nuclear. In the year 2050, then, according to the above assumed growth rates, 77 percent of the electrical power generation in the U. S. A. would have a nuclear source.

As a starting point for the growth of nuclear energy in the U. S. A., it was assumed that in the year 1965, 7.5×10^6 kwh of electrical energy would be generated from nuclear sources. This assumption is based on a 1.5×10^6 kw capacity and a 5000 hour-per-year-average operating time per nuclear plant.

D. COMPARISON WITH OTHER ESTIMATES OF NUCLEAR ENERGY PRODUCTION

Figure 6 shows a comparison of various predictions of the annual total electrical and the annual nuclear electrical energy production in the U. S. A. The equation discussed above for the annual world total electrical energy production is also shown in Figure 6 for comparison.

The prediction of the annual total electrical energy production in the U. S. A. which is made in the present paper is shown on Figure 6 to be between predictions made by the Federal Power Commission and by Putman, and is in good agreement with both of these. The predictions of the present paper extend much further into the future than these other predictions, however. Other references shown on Figure 6 predict the U. S. electrical energy production to be 50 percent or more of the predicted total world electrical energy production. It should be expected that in the future the U. S. A. will produce a decreasing portion of the total world electrical energy.

In some of the references, only the net installed electrical capacity was predicted rather than the annual energy production. In order to show these data on Figure 6, an average equivalent full-power operating time of 5000 hours per year was assumed.

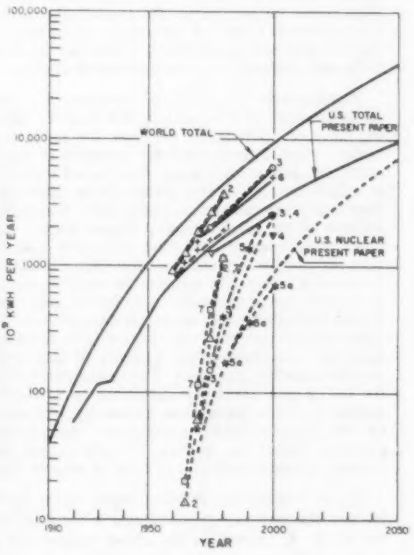

Figure 6. Comparison of Predictions of Annual Electrical Energy Production.

(Solid lines are annual total electrical energy production and dashed lines are annual nuclear electrical energy production. An equivalent full-power operating time of 5000 hours per year was assumed.)

Symbol	*Reference No.*	*Reference*
+	1	"Statistical Abstract of the United States, 1958" (U. S. Department of Commerce, Bureau of the Census) page 528
△	2	Karl Cohen, "Charting a Course for Nuclear Power Development," Nucleonics *16*, 66 (Jan. 1958)
⊙	3	Statement of Philip Sporn before the Subcommittee on Automation and Energy Resources, Joint Economic Committee, Oct 12, 1959
▽	4	Palmer C. Putman, *Energy in the Future*, (New York: D. Van Nostrand Co., Inc., 1953)
•	5 & 5a	J. A. Lane, *D.O Moderated Power Reactors, A Symposium, March 3-4, 1959*, TID-7575, "Future R.quirements for D.O," page 15. The points labelled 5 are based on Lane's average projected capacity, and the points labelled 5a are based on his minimum projected capacity.
X	6	E. I. Hughes and N. C. Nelson, *Proceedings of the International Conference on the Peaceful Uses of Atomic Energy, 1955*, Vol *1*, "A Century of Growth of Electric Power Requirements in the United States," page 245.
⊡	7	W. K. Davis, L. H. Roddis, and C. Goodman, "Power Reactors–The Government View," Nucleonics *15* (9), 90 (Sept. 1957)

IV. URANIUM REQUIREMENTS

A. *REQUIREMENT BASED ON A GIVEN REACTOR TYPE*

Uranium requirements can be calculated directly from the predictions of nuclear electrical generation, if the characteristics of the average nuclear power station are known. The converter reactor types now under development can be divided into two general classes according to the characteristics which affect uranium requirements and fuel cycle costs. First, there are reactors which operate at relatively high coolant outlet temperatures and high specific powers. These reactor plants have relatively high thermal efficiencies and low fuel inventories. This class will be called high T. and S. P. (Temperature and Specific Power). Second, there are reactors which operate at relatively low coolant outlet temperatures and low specific powers. These reactor plants have relatively low thermal efficiencies and high fuel inventories. This second class will be referred to as low T. and S. P. Reactors which fit into the first class are the liquid-metal-cooled reactors, of which the Sodium Graphite Reactor will be used as an example. Reactors which fit into the second class include the water- and the organic-cooled designs. The organic-cooled reactor[12] will be used as a typical example of reactor in the low T. and S. P. class. Characteristics which relate to the uranium requirements for each of these reactor types are given in Table I.

TABLE I

Characteristics of Reactor Types Which Relate to the Uranium Requirements and Uranium Burnup Costs

	HIGH T. and S.P.	Low T. and S.P.
Initial Fuel Enrichment, % U^{235}	2.50	2.50
Average Enrichment of Discharged Fuel, % U^{235}	1.105	1.195
Plutonium Content of Discharged Fuel, gm/kg U	5.80	7.83
Initial Conversion Ratio	0.51	0.65
Average Fuel Burnup, Mwd/MTU	15,000	15,000
Net Plant Efficiency, %	42.6	31.0
In-Core Uranium Inventory, kg/Mwe	63	176

For the present calculation of uranium requirements, it will be assumed that future nuclear electrical plants have characteristics similar to the High T. and S. P. class. The Sodium Graphite Design used to obtain the data in Table I represents some extension in technology over the Hallam reactor, which is now under construction, particularly in the proposed use of uranium carbide fuel material which will enable operation at a higher specific power. However, it is believed that the numbers used represent a feasible extension in technology of a relatively few years in time.

If 1 percent total loss in processing of the discharged fuel elements is assumed, then the discharged fuel material from 1 kg of fuel loaded into the reactor could be re-enriched in the gaseous diffusion plant to produce 0.377 kg uranium with the correct loading enrichment of 2.5 percent. An additional 0.623 kg of 2.5 percent enriched uranium would be required to provide a new reactor loading of 1 kg, and this additional material would require 2.88 kg of natural uranium to manufacture. Thus, an energy of 15,000 Mwd(th) can be obtained from 2.88 metric tons of natural uranium without taking credit for the plutonium which is recovered from the discharged fuel. This plutonium recovered could be burned to produce about 3800 Mwd(th) per metric ton of fuel loaded into the reactor, if this plutonium were used in a burner to obtain 1 Mwd per 1.48 gm of plutonium. With credit for plutonium, the equivalent burnup is 6520 Mwd(th)/MT of natural U. Assuming the thermal efficiency given above, 1 short ton of natural U_3O_8 will produce 51.3×10^6 kwh of electricity.

Requirements for uranium inventory are based on an assumption of an equivalent full-power operating time of 5000 hours per year for the average nuclear plant. Present plans for operation of nuclear plants are as base load plants, but it is not reasonable to expect that all nuclear plants can be operated as base load when the nuclear plants reach a significant fraction of the total capacity. Approximately 5000 hours is the average equivalent full-power operating time per year for the central station electrical capacity in the U. S. today. The trend in the utility industry is to smooth out load peaks, and future plants may have a somewhat larger operating time per year. The total uranium inventory was assumed to be the in-core inventory plus the average quantity of fuel loaded into the reactor each year. This assumption allows for an ex-core inventory equivalent to a one-year holdup of fuel in fabrication, processing, and spares. On the basis of these assumptions, the electrical capacity needed to produce 10^9 kwh in one year requires an inventory of 116 tons of natural U_3O_8.

Figure 7 shows the uranium requirements for the nuclear electrical energy production in the world and the U. S. A., based on the above assumptions of reactor performance and on the predictions of nuclear electrical energy production shown in Figure 5. The data on uranium requirements indicate that the uranium available in the U. S. A. at present prices will

support the projected nuclear electrical industry in this country until the year 2005, and the uranium available in the world at present prices will support the projected nuclear electrical industry in the world until the year 2038. The total uranium requirement for the nuclear electrical industry in the U. S. A. until the year 2050 is predicted as 4.7 million tons of U_3O_8. Based on the uranium resource predictions illustrated in Figure 3, this quantity of uranium would be available at a price of $23 per pound, assuming no imports. World requirements to the year 2050 are predicted as only 1.55 times the world availability at present prices; hence, very little price increase would be required to provide the necessary supply. If the present price is taken as $8 per pound of U_3O_8, an increase of only about $1.50 per pound to $9.50 per pound would be sufficient to provide a world supply to the year 2050.

B. EFFECT OF REACTOR DESIGN PARAMETERS ON URANIUM REQUIREMENTS

The uranium requirements given above are based on a reactor design which represents relatively small extensions of present technology. Thus, there is an element of pessimism in the estimates, since they do not allow for future improvements in reactor performance. For example, an improvement in the initial conversion ratio from the value of 0.51 assumed above will improve the energy obtained per ton of natural uranium and will decrease the uranium requirements. Increasing the fuel burnup in the reactor will also improve the utilization of natural uranium. Figure 8 shows the effect of conversion ratio and of burnup of fuel in the reactor on the equivalent burnup of natural uranium in a sodium graphite reactor. Data in this figure are based on an enrichment of 0.22 percent for the waste from the diffusion plant used to enrich the uranium. If the conversion ratio could be increased to 0.70 and the average fuel burnup could be increased to 22,000 Mwd/MT, the energy obtained from one ton of natural uranium would be increased by more than one-third. These extensions of reactor technology appear to be reasonable goals for the next few decades and, if accomplished, would prolong the time before an increase in the price of natural uranium would be necessary.

Other improvements in reactor characteristics could also decrease the uranium requirements. These include an improvement in the specific power and in the net plant efficiency. However, in order to achieve a large increase in the energy obtained from 1 ton of natural uranium, it appears that a more efficient method of using the plutonium produced is required. A fast plutonium breeder could accomplish this objective, but relatively large increases in the energy from natural uranium could be obtained with a fast plutonium reactor having a high conversion ratio even though the conversion ratio might not be sufficiently high to give breeding. Another method of using the

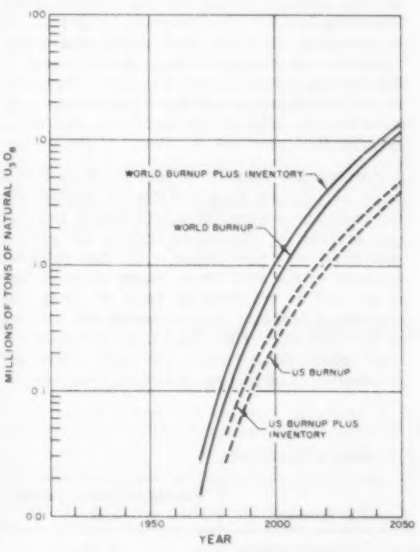

Figure 7. Uranium Requirements for Nuclear Energy.

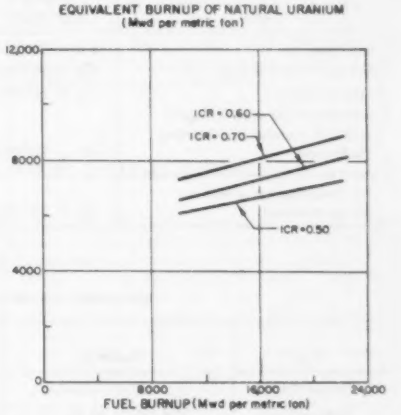

Figure 8. Equivalent Burnup of Natural Uranium in an Enriched Uranium Fuel Cycle.

plutonium more effectively than in a simple burner would be in a plutonium recycle system. Use of plutonium in the fuel would permit a lower uranium enrichment to be used and would increase the energy obtained per gram of U^{235} feed. Although not considered in the above predictions, the use of a reactor which will burn plutonium efficiently appears likely at some future time, since the operation of power reactors will produce a large stockpile of reactor grade plutonium.

V. COMPARISON OF CONVENTIONAL FUEL AND NUCLEAR FUEL RESERVES AND RESOURCES

The reserves and resources of conventional fossil fuels have recently been discussed in some detail by Bruce C. Netschert[g] in testimony before the Joint Economic Committee. He points out the difficulty in comparing data on reserves of fossil fuels because of the different bases on which the reserves are calculated and because of the different definitions of reserves as applied to the various fuels. In general, reserves of crude oil are given as proved reserves from which the oil can be economically recovered at present prices, while reserves of coal are given as estimates of total amount of coal which would be feasible to recover. The reserves of uranium are given on a basis which is similar to that used for crude oil.

For purposes of comparing the energy content of the fuel reserves, the energy equivalents shown in Table II are used.

TABLE II

Energy Equivalents of Fuels

Fuel	Energy Equivalent
1 bbl crude oil	5.8×10^6 Btu
1000 cu. ft natural gas	1.0×10^6 Btu
1 short ton coal	25×10^6 Btu
1 short ton U_3O_8 used in high T. and S.P. reactor plus burning Pu formed	0.41×10^{12} Btu
1 short ton U_3O_8 used in hypothetical breeding cycle with no losses assumed	50×10^{12} Btu

The energy equivalent of 1 short ton of U_3O_8 used in the high T. and S.P. reactor fuel cycle is the thermal equivalent of the energy used for the calculation of uranium requirements in the previous section. This energy equivalent is slightly lower than that for a low T. and S.P. reactor because of the lower conversion ratio assumed. The energy equivalent of the Pu produced was assumed to be 1.48 gm Pu per Mwd(th).

The energy equivalent of 1 short ton of U_3O_8 used in a breeding cycle was calculated with the assumption that each 1.25 gm of uranium would produce 1 Mwd(th). This assumption allows for the same average capture-to-fission ratio as the thermal neutron value for U^{235}. No allowance is made for losses in fabrication, initial enrichment, or chemical processing of the fuel; hence the energy equivalent used for the breeding cycle is an upper limit. An energy equivalent based on present fast breeder technology would be at least a factor of two lower than that shown in Table II.

Authoritative estimates of reserves of fossil fuels in the U.S.A.[g] are given in Table III together with the equivalent energy content calculated from the data in Table II. The energy contents are given in units of Q, where Q is defined as 10^{15} Btu. Published estimates of the total future supply of fossil fuels in the U.S.A. are given in Table IV along with Netschert's estimates[g] of the resource base for each of the fossil fuels. These data show that there is a much greater factor between the resource base and the reserves of oil and gas than there is for coal.

TABLE III

Authoritative Estimates of U. S. Reserves of Fossil Fuels

Fuel	Quantity	Source of Estimate	Equivalent Energy Content in Q
Crude Oil	30.5 billion barrels	American Petroleum Institute	0.18
Natural Gas	254 trillion cu. ft.	American Gas Association	0.25
Coal	950 billion short tons	U.S. Geologic Survey	24

TABLE IV

Estimates of Total Future U. S. Supply and of Resource Base of Conventional Fuels

Future U. S. Supply			U. S. Resource Base	
Fuel	Quantity	Energy Equivalent in Q	Quantity	Energy Equivalent in Q
Crude Oil	140-250 × 10^{9} bbl	0.8-1.4	500 × 10^{9} bbl	2.9
Gas	500-1200 × 10^{12} cu. ft.	0.5-1.2	1200 × 10^{12} cu. ft.	1.2
Coal	1.9 × 10^{12} short tons	48	2.0 × 10^{12} short tons	50

TABLE V

Uranium Fuel in the U. S.

	Quantity, Short Tons U_3O_8	Thermal Energy Equivalent in Q	
		High T. and S. P. Fuel Cycle	Breeding Cycle (losses unknown)
Reserves at Present Prices	0.5 × 10^{6}	0.2	12-25
Resource Base	3 × 10^{11}	120,000	7-15,000,000

Estimates of the uranium reserves and resource base in the U. S. A. are given in Table V. The uranium reserves of 0.5 × 10^{6} tons at present prices were taken from Section II above. The resource base of 3 × 10^{11} tons is the estimated uranium content of the earth's crust under the U.S. to a depth of 2 miles and is calculated from an average uranium content of 4 parts per million by weight. A range of energy equivalents is shown for the breeding cycle which corresponds to overall losses of from 0 to 50 percent. A comparison of Tables III and V indicates that the energy content of the reserves of uranium are comparable to the energy content of the reserves of oil or gas if a present technology fuel cycle is assumed for the uranium. However, the resource base for uranium has an energy equivalence many orders of magnitude greater than for fossil fuels. The ratio of the resource base to the reserves is much greater for uranium than for fossil fuels.

The total thermal energy requirement for the production of all the electrical energy in the U.S. from 1960 to 2050 at an average thermal efficiency of 35% is 3.5Q. This quantity of energy is somewhat greater than the equivalent of the present U. S. reserves of all fuels except coal. However, the resource base for uranium is a factor of about 35,000 larger than this value of 3.5Q.

VI. EFFECT OF URANIUM PRICE ON FUEL CYCLE ECONOMICS

A. PRICE OF ENRICHED URANIUM

A possible change in the price of natural U_3O_8 will affect the fuel cycle cost for nuclear energy production. In order to evaluate the effect of the price of natural U_3O_8 on fuel cycle cost, the effect on the price of enriched uranium was first calculated. Equations for an ideal gaseous diffusion cascade[12, 13, 15] were used for this purpose. The present AEC price schedule for enriched uranium as UF_6 can be fitted by the equations for an ideal cascade with the cost of separative work at $37.29 per kg and the cost of natural UF_6 feed material at $39.27 per kg.[12, 13] It is assumed that the U^{235} concentration of the waste material is the optimum value, which is found to be 0.22 percent for these separative work and feed costs. If the $37.29 per kg cost for the feed is based on a $10 per pound price for U_3O_8 concentrate, then $13.28 per kg of uranium has been allowed for fluorination and preparation of the feed material. For calculation of the price of enriched uranium, with higher prices for natural uranium, it was assumed that the same cost for fluorination and preparation of the feed material would apply, and also that the cost per unit of separative work would not change.

As the price of natural uranium increases, it is economical to perform more separative work on each kg of feed material, thereby decreasing the optimum concentration of U^{235} in the waste material. Figure 9 shows the variation of the optimum concentration of U^{235} in the waste material as the price of natural uranium increases. If natural U_3O_8 were to cost \$20 per lb, the optimum waste concentration under the above assumptions would be about 0.17 percent.

Calculation of the price of enriched uranium as UF_6 was based on the optimum concentration of U^{235} in the waste material. Prices of enriched uranium as UF_6 are shown in Figure 10 for various prices of natural uranium as U_3O_8.

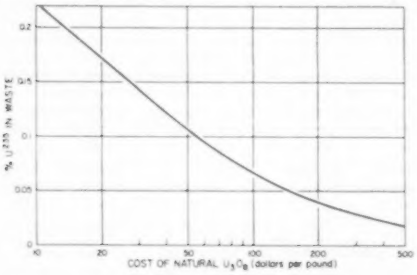

Figure 9. Optimum Concentration of U^{235} in Waste from Gaseous Diffusion Plant for Increasing Costs of Natural Uranium Feed.

As an example of the effect of natural uranium price on the price of enriched uranium, increasing the price of natural uranium from \$10 to \$20 per lb of U_3O_8 will increase the price of 2.5 percent enriched uranium as UF_6 from \$297 per kg to \$412 per kg. At \$50 per lb for natural U_3O_8, the price of 2.5 percent enriched uranium is \$731 per kg.

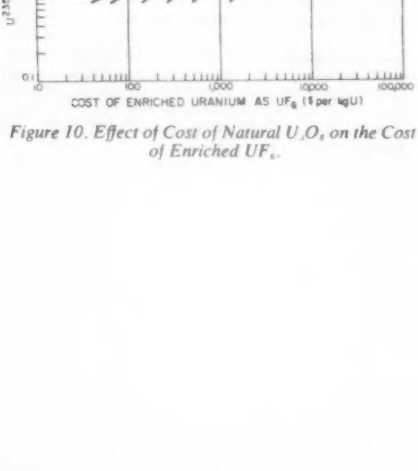

Figure 10. Effect of Cost of Natural U_3O_8 on the Cost of Enriched UF_6.

B. FUEL CYCLE COSTS

The effect of the price of natural uranium on the fuel cycle cost was investigated. The prices for enriched uranium, calculated as discussed above, were used to determine fuel burnup charges and fuel inventory charges. Other assumptions include the following:

(1) The annual fuel use charge was assumed to be 4 percent of the value of the uranium inventory as UF_6.

(2) Total fuel inventory was assumed to be the in-core inventory plus an ex-core inventory equal to the annual throughput. This ex-core inventory allows a one-year holdup of fuel for fabrication, processing, and spares. The equivalent full-power operation per year was assumed to be 5000 hours. These assumptions are the same as those used for the calculation of uranium requirements above.

(3) The value of plutonium was assumed to be a constant fraction of the cost of U^{235} in 90 percent enriched uranium.

(4) The \$1.50 per gram cost of converting plutonium metal has been subtracted from the amount allowed for plutonium credit.

Fuel cycle costs for the high-temperature and high-specific-power reactor are shown in Table VI for various prices of U_3O_8. The same assumptions on fuel depletion and burnup were made as for the calculation of the uranium requirements above. The initial conversion ratio for this reactor is 0.51. All costs associated with fabrication of fuel elements and with chemical processing of the fuel were assumed to total \$117 per kg of fuel loaded into the reactor. If the cost of natural U_3O_8 were to increase from \$10 to \$20 per lb, the fuel cycle cost would increase from 1.94 to 2.35 mills per kwh or only 0.41 mill per kwh.

If the initial conversion ratio of the reactor could be increased, the fuel cycle costs would be reduced and would become less sensitive to the price of natural uranium. Figure 11 shows the fuel cycle cost as a function of natural uranium for various initial conversion ratios. Variations in conversion ratio were assumed not to affect the other parameters that also influence fuel cycle cost, such as initial fuel enrichment. The effect of conversion ratio on fuel cycle cost is also shown in Figure 12, which is a cross plot of the data in Figure 11.

The data in Figures 11 and 12 indicate that a conversion ratio substantially higher than 1.0 is required before the fuel cycle costs become independent of the price of natural uranium. There are two important reasons for this effect:

(1) The fuel use charge is significant and will vary with uranium price even though the net burnup charge is zero. In order to make the

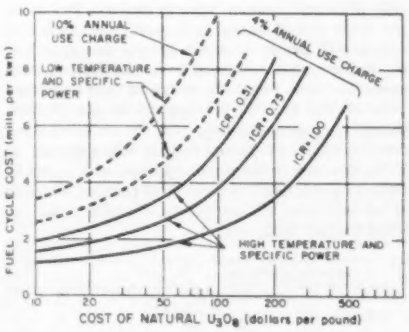

Figure 11. Variation in Fuel Cycle Cost if the Cost of Natural U_3O_8 is increased.

fuel cycle cost independent of uranium price, the burnup charge must give a sufficient profit to pay the inventory charge.

(2) The fuel cycle converts U^{238} into plutonium, which is a less valuable fuel. Thus, even with a conversion ratio of 1.0, there would be a net charge for fuel burnup.

As the conversion ratio is increased, the fuel cycle cost is decreased, but there is no discontinuity in the variation. Thus, in terms of fuel cycle cost there is no sharp distinction between a breeder with conversion ratio slightly greater than 1 and a converter reactor with a conversion ratio slightly less than 1. A high conversion ratio is a desirable goal, if it can be used to lower the fuel cycle cost without introducing other factors which would create compensating higher costs. However, it should be pointed out that a conversion ratio of 1.0 is entirely satisfactory, since it acts to give a sharply lower cost.

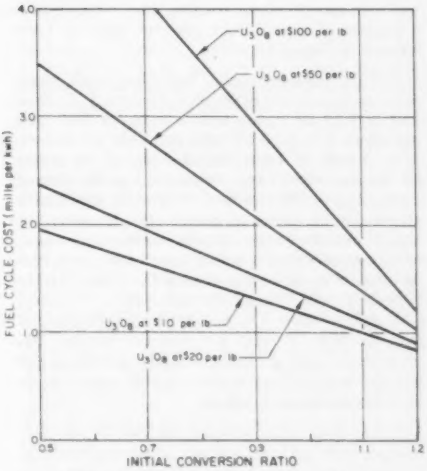

Figure 12. Effect of Conversion Ratio on Fuel Cycle Cost.

The influence of the price of natural uranium on the fuel cycle cost for the low-temperature and low-specific-power reactors was also investigated. It was assumed that the total costs associated with the fabrication and chemical processing of the fuel were $117 per kg of fuel loaded into the reactor. This is the same assumption as used for the high-temperature

TABLE VI

Fuel Cycle Cost in Mills/Kwh for the High-Temperature and High-Specific-Power-Reactor as the Cost of Natural U_3O_8 Is Increased

Item	Cost of Natural U_3O_8, $/lb					
	10	20	50	100	200	500
Fabrication and Processing	0.76	0.76	0.76	0.76	0.76	0.76
Fuel Use Charge (4% per annum on value of inventory as UF_6)	0.23	0.32	0.57	0.95	1.70	3.96
Fuel Burnup	1.35	1.80	3.00	4.89	8.45	18.75
Sub-Total	2.34	2.88	4.33	6.60	10.91	23.47
Plutonium Credit (Pu price proportional to price of 90% U^{235})	0.40	0.53	0.88	1.43	2.46	5.49
Net Fuel Cycle Cost	1.94	2.35	3.45	5.17	8.45	18.00

and high-specific-power reactors. Fuel cycle costs as a function of natural U_3O_8 price are given in Table VII and in Figure 11.

For the low-temperature and low-specific-power reactors, an increase in the cost of natural U_3O_8 from \$10 to \$20 per pound will increase the fuel cycle cost from 2.57 to 3.13 mills per kwh, an increase of 0.56 mill per kwh. The similarity of the curves for the two reactor types indicates that the general conclusions on fuel cycle cost are not significantly affected by the choice of reactor type. However, the high T. and S.P. reactors are less sensitive to increases in the cost of natural uranium, since in this latter case an increase in the cost of natural U_3O_8 from \$10 to \$20 per lb will increase the fuel cycle cost by only 0.41 mill per kwh. The reason for this difference is that the high T. and S.P. reactors require less uranium per unit of electrical energy produced, and thus the use of these reactors would contribute to the conservation of uranium.

Present fuel cycle costs for the low T. and S.P. reactors with U_3O_8 at \$10 per lb are equivalent to the costs for the high T. and S.P. reactors with U_3O_8 at \$26 per lb. This comparison assumes that the costs for fabrication and chemical processing of the fuel are the same for either type of reactor. An increase of the price of U_3O_8 to \$26 per lb would increase the available resources by a factor of 6.8.

As reactor technology advances, the neutron economy of power reactors should improve. This in turn will decrease the fuel cycle cost, which will tend to counterbalance a possible increase in fuel cycle cost because of the increase in cost of natural uranium. Figure 13 shows the conversion ratio which would be needed to maintain the present fuel cycle cost if the cost of natural uranium were to increase. For example, if the cost of natural U_3O_8 were to increase from \$10 to \$20 per lb, then the present fuel cycle cost for the reference design could be maintained if the conversion ratio were to be increased from the present value of 0.51 to 0.70. This appears to be a plausible increase in conversion ratio over the period of many decades which is expected to pass before the cost of U_3O_8 increases to the predicted value of \$20 per lb. Other improvements in the reactor performance such as an improved specific power would also tend to lower the fuel cycle cost.

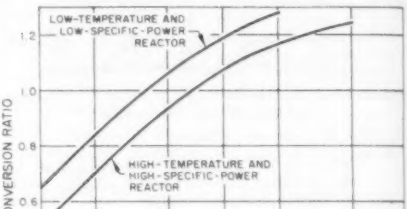

Figure 13. Conversion Ratio Required to Maintain Constant Fuel Cycle Cost as the Cost of Natural U_3O_8 Increases.

TABLE VII

Fuel Cycle Cost in Mills/Kwh for the Low-Temperature and Low-Specific-Power Reactor as the Cost of Natural U_3O_8 Is Increased

Item	Cost of Natural U_3O_8, \$/lb					
	10	20	50	100	200	500
Fabrication and Processing	1.05	1.05	1.05	1.05	1.05	1.05
Fuel Use Charge (4% per annum on value of inventory as UF_6)	0.52	0.73	1.29	2.18	3.88	8.80
Fuel Burnup	1.74	2.33	3.98	6.35	10.90	24.30
Sub-Total	3.31	4.11	6.32	9.58	15.83	34.20
Plutonium Credit (Pu price proportional to 90% U^{235})	0.74	0.98	1.64	2.68	4.60	10.20
Net Fuel Cycle Cost	2.57	3.13	4.68	6.90	11.23	24.00

VII. CONCLUSIONS[m]

A study of the resources of uranium indicated that the resources available are strongly dependent on the price. Uranium resources were found to increase approximately as the square of the price.

Based on the assumptions given above for the use of uranium for nuclear power generation in the U.S.A., there should be sufficient uranium available *in the U.S.A.* at present prices to support the nuclear power industry until *the year 2005*. Assuming that there are no imports of uranium into this country, and assuming reactor characteristics that are likely to be attained within 10 years, there should be sufficient uranium to support the nuclear power industry in the U.S.A. until the year 2050 if the price of U_3O_8 were to increase to $23 per pound. This increase in the cost of natural uranium should increase the fuel cycle cost by about 0.5 mill per kwh. However, improvements in reactor technology which may reasonably be expected to occur before 2050 should offset the effect of increasing uranium cost. For example, if the initial conversion ratio were to increase from the value of 0.51, which was assumed for calculation of uranium requirements and fuel cycle cost, to a value of 0.74, the savings in fuel cycle cost will compensate for an increase in the cost of U_3O_8 of $23 per pound. Other improvements which may be expected to occur by the year 2050 can also lower the fuel cycle cost. These other improvements could include higher specific power, improved isotope separation facilities, and more rapid and less costly chemical reprocessing.

If the world consumption of uranium is considered, it appears that there will be sufficient uranium to support the nuclear power industry until the year 2050 if the price increases by an amount which is less than the present spread in prices from different sources. If the present price is assumed to be $8 per pound of U_3O_8, the increase required by the year 2050 would be about $1.50, to $9.50 per pound. Since present prices for enriched uranium are probably based on higher costs than $9.50 per pound for natural U_3O_8, there would be no apparent increase in fuel cycle costs by the year 2050. Improvements in reactor technology before 2050 would certainly lower fuel cycle costs. Thus, on a world basis there is less urgency for conservation of uranium than if the U.S.A. is considered as an isolated producer and consumer.

Improvements in conversion ratio and fuel burnup per pass through the reactor would not only lower the fuel cycle cost, but would also increase the amount of energy available per ton of natural uranium, thereby decreasing the amount of uranium required. An increase in conversion ratio from 0.51 to 0.70 and an increase of the average fuel burnup from 15,000 to 20,000 Mwd/MT would decrease the uranium required for burnup by 23 percent. This possible decrease has not been considered in the calculation of the uranium requirements.

Comparison of the data on fuel cycle costs for the high-temperature and high-specific-power reactors with the data for the low-temperature and low-specific-power reactors indicates that a smaller quantity of uranium is required for generation of a given quantity of electrical power if the high-temperature and high-specific-power reactors are used. Also, if the price of uranium were to increase, the resultant increase in the fuel cycle cost will be less for the high T. and S.P. reactor than for the low T. and S.P. reactors. For example, if the price of natural U_3O_8 were to increase from $10 to $20 per lb, the fuel cycle cost for the high T. and S.P. reactors would increase 0.41 mill per kwh, while the fuel cycle cost for the low T. and S.P. reactors would increase 0.56 mill per kwh. Thus, the characteristics of the reactor will affect its sensitivity to a possible scarcity of uranium.

Present fuel cycle costs with the low T. and S.P. reactors are equivalent to costs for the high T. and S.P. reactors with uranium at a cost of $26 per lb of U_3O_8. This comparison assumes the same costs for fabrication and chemical processing of the fuel for either type of reactor. An increase in the cost of U_3O_8 from $10 to $26 per lb would increase the available resources by a factor of 6.8.

In order to realize larger increases in the energy obtained per unit weight of natural uranium than can be obtained by improvements in the reactor types considered in this paper, more efficient burning of the plutonium formed in a uranium-fueled reactor will be necessary. Increased efficiency in plutonium consumption would require a fast reactor or a plutonium recycle system. Relatively large gains in the energy obtainable from natural uranium could be obtained by development of a reactor for burning plutonium with a reasonably high conversion ratio, even though true breeding (conversion ratio greater than 1.0) is not achieved.

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APPENDIX 12

OLD PROVISIONAL CONSTRUCTION PERMIT

1 CRITERIA

(1) Reasonable Assurance that a facility of the general type proposed can be constructed and operated at the proposed location without undue risk to the health and safety of the public;

(2) Reasonable Assurance that technical information required to complete the application will be supplied by the applicant;

(3) The applicant is technically and financially qualified to engage in the proposed activities;

(4) Issuance of the construction permit would not be inimical to the common defense and security or to the health and safety of the public.

NEW PROVISIONAL CONSTRUCTION PERMIT

1 CRITERIA

(1) Reasonable assurance that the proposed location is suitable from a safety standpoint for a facility of the size and general design concept proposed;

(2) The major features or components on which further research and development work is needed to assure the safety of the facility have been identified;

(3) Same

(4) Same

(5) Applicant will conduct a research and development program to investigate the unresolved safety questions.

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